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THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents: (1) progress reports on long-term major research projects; (2) final reports on short-term projects and (3) short, timely articles of a popular nature that bring together information from various sources on subjects in which farmers are interested.

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CONCENTRATION OF JUICE FROM MICHIGAN FRUITS BY FREEZING[1]

By PAULINE PAUL
SECTION OF FOODS AND NUTRITION

FRUIT JUICES are bulky and require much space for storage. Therefore, methods have long been sought for preparing juice concentrates or syrups which would retain the natural flavor and aroma of the original fruit. Concentration by heating presents difficulties, as many of the constituents responsible for the natural flavor are volatile and are carried off with the steam. Also heat produces "cooked" flavors, so that the resulting concentrates frequently differ widely in flavor from the original fruit juices.

The concentration of fruit juices by partial freezing and separation of the ice has been worked on for a number of years (1). Several successful methods have been developed, but have not been adopted commercially because of the expense involved. With the recent development of refrigeration equipment, this problem is again being studied. In Florida, equipment for concentrating citrus juices has been developed and the process carried through the pilot plant stage (3).

Concentration by freezing involves freezing the juice to a slush, then separating the liquid from the ice, usually by centrifugation. This process is based on the principle that, at temperatures at or just below the freezing point of water (32° F.), part of the water will freeze as pure ice but that lower temperatures are required to freeze the whole mass. The ice is separated from the juice by centrifugation in a perforated basket which retains the ice crystals. This process has been applied to juices obtained as by-products from the preparation of purées from Michigan fruits (2). Black raspberry, sour cherry, tomato, plum and grape juices have been used. Successful concentrates were made from the black raspberry, sour cherry, plum and grape juices. Tomato juice concentrates were not successful, as the beverages re-

[1]The study upon which this report is based was supported in part by funds from the Rackham Research Endowment.

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sulting from dilution of the concentrates were very thin and lacked body.

Three successive concentrations from the same batch of grape juice have been made, the final volume in each case being approximately one-third that of the original juice. Determinations of total solids and ascorbic acid content of the original juices, the concentrates, and the ice residues indicated that there was appreciable concentration of the solids. These data are given in Table 1. In some cases, the percent total solids in the ice was fairly high. This was due to retention in the ice fraction of any fragments of fruit pulp or seeds, rather than soluble solids. The total solids in the grape juice ice were increased by the presence of crystallized tartrates.

Samples of the various original juices and concentrates were held in frozen storage, then defrosted, made up to beverage strength and scored. The data on these are given in Table 2. The diluted grape concentrates were preferred over the original grape juice, the highest concentrate receiving the best score. The plum beverage was considered good, but the plum juice was thick and quite viscous. The cherry juice was too tart and the black raspberry too flat, even in the original juice. However, they made an excellent beverage when used in com-

TABLE 1—*Yield, total solids and ascorbic acid content of original juices, concentrated juices and ice residues of fruit juices concentrated by freezing and centrifugation.*

Fruit	Percent yield (by weight)		Percent total solids		Ascorbic acid content mg./100 gm.	
	Juice	Ice	Juice	Ice	Juice	Ice
Grape						
original juice	.....	.....	11.82	.....	3.9	.....
1st concentration	72.4	25.4	14.04	3.22	3.5	1.1
2nd concentration	68.0	28.8	20.44	.....	4.8	0.0
3rd concentration	76.2	20.6	28.79	4.2	6.9	1.0
Plum						
original juice	.....	.....	19.57	.....	6.0	.....
concentrate	61.5	34.6	31.00	1.63	9.1	1.0
Cherry						
concentrate	68.8	21.9	21.93	1.87	9.6	0.8
Black raspberry						
original juice	.....	.....	5.82	.....	5.5	.....
concentrate	62.5	29.2	8.43	0.40	6.5	0.0

TABLE 2—*Degree of dilution, amount of sugar added, and rank scores for fruit beverages.*

Fruit	Actual percent of original (by weight)	Dilution		Weight ratio of sugar added	Rank score	Method of scoring
		Percent concentrate	Percent water			
Grape						
original	100.0	no dilution	.....	1:30	2.9	Ranked from 1 to 4 most desirable being given lowest rank. Figure is average of rank scores obtained.
1st concentrate	72.4	60	40	1:30	2.7	
2nd concentrate	49.2	50	50	1:30	2.3	
3rd concentrate	37.5	33	67	1:35	2.2	
Plum						
original	100.0	67	33	1:140	1.7	Ranked from 1 to 2, most desirable being given lowest rank. Figure is average of rank scores obtained.
concentrate	61.5	33	67	1:70	1.3	
Cherry						
original	100.0	67	33	1:25	1.3	Same as for plum
concentrate	68.8	33	67	1:30	1.7	
Black raspberry						
original	100.0	no dilution	.....	1:50	1.1	Same as for plum
concentrate	62.5	67	33	1:70	1.9	

bination. It was suggested that several of the beverages might be improved by using carbonated rather than plain water for dilution.

The grape and plum concentrates were also tested as ice cream sauces. The concentrates were sweetened and used without dilution on vanilla ice cream. The judges stated that these sweetened concentrates made excellent sundae sauces.

The process of concentration of fruit juices by freezing and centrifugation seems to hold possibilities for the production of fruit concentrates which will retain the fresh fruit flavor and will be suitable for commercial use by soda fountains, and also consumer utilization in the home.

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DESTRUCTION OF QUACKGRASS RHIZOMES BY APPLICATION OF ISOPROPYLPHENYLCARBAMATE

By R. F. CARLSON
SECTION OF HORTICULTURE

THE HERBICIDAL PROPERTIES of O-isopropyl N-phenylcarbamate have been explored by Allard *et al.* (1). They found in greenhouse tests that this chemical was effective against seedlings of certain cereal crops when applied to the soil in aqueous solutions at the rate of 1½ to 6 milligrams per 4-inch pot. Further, it was selective in action, having no injurious effects on such economic plants as kidney beans, soybeans, cowpeas, sunflowers, radishes, turnips, and sugar beets at concentrations which were destructive to several cereal crops. Ennis (2) subsequently found that this material had no effect when applied to the tops of oat and barley seedlings, whereas soil applications of 5 milligrams per 4-inch pot were lethal to the same plants. The fact that many grasses are sensitive to isopropylphenylcarbamate suggested studies to determine its effect on rhizomes of quackgrass, *Agropyron repens* L, which is a serious weed in many parts of the country.

EXPERIMENTAL

In the fall of 1946, pieces of quackgrass rhizomes, 24 centimeters in length, were dipped in an aqueous solution of isopropylphenylcarbamate at 1,000 p.p.m. and then planted 50 to the flat in moist soil in a greenhouse at a temperature of about 70° F. Other rhizomes of the same length were planted without treatment as checks. Since isopropylphenylcarbamate is only slightly soluble in water, it was first dissolved in 50 grams of carbowax 1500 (polyethylene glycol) (4) and then mixed with one liter of water. The chemical is also soluble in glacial acetic acid and this substance can be used instead of carbowax. When prepared in this way the chemical goes into solution.

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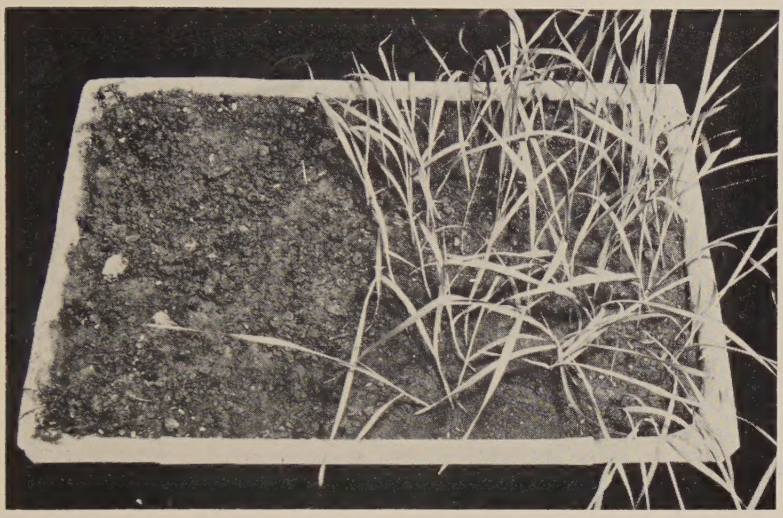

Fig. 1. Quackgrass rhizomes in the left half of the flat were dipped in 1,000 p.p.m. solution of isopropylphenylcarbamate before planting, and those in the right half were dipped in water.

Within two weeks, untreated rhizomes had developed abundant shoot growth whereas treated rhizomes showed no growth (Fig. 1). One month after planting the treated rhizomes were examined, and it was found that the buds were dead. The rhizomes were replanted after examination and held for 4 months, during which time no shoots appeared.

In order to determine the lower limits of effectiveness of isopropylphenylcarbamate, a range of 10 concentrations in duplicate were used

TABLE 1—*Effect of isopropylphenylcarbamate upon rhizomes of quackgrass as indicated by the number of shoots appearing 8 to 40 days after treatment.*

Concentrations (parts per million)	Number of shoots present at indicated number of days following treatment								
	8	11	14	18	23	25	29	35	40
100	2	2	6	7	9	9	10	12	14
200	1	1	2	3	4	5	5	5	5
300	0	0	0	0	0	0	0	1	1
400	1	1	1	1	1	1	1	1	1
500	0	0	1	1	1	1	1	1	1
600	0	0	0	0	0	0	0	0	0
700	0	0	0	0	0	0	0	0	0
800	0	0	0	0	0	0	0	0	0
900	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0
Control	21	76	113	132	132	137	139	144	147

as follows: 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1,000 p.p.m. At the end of three weeks, the untreated rhizomes had produced an abundance of new shoots, those treated with less than 500 p.p.m. had produced only a few shoots, and those treated with amounts above 500 p.p.m. had produced no growth (Table 1 and Fig. 2).

In another experiment, rhizomes were placed on soil in flats and sprayed with isopropylphenylcarbamate before being covered with soil. The concentrations of the chemical and other conditions were the same as in the preceding experiment. The sprayer used was of the atomizing-nozzle type described in a recent publication (3).

The injury to the rhizomes following spraying was similar to that observed where the rhizomes were dipped in the solution. With concentrations of isopropylphenylcarbamate above 500 p.p.m. there were no new shoots, and below this level the effectiveness of the chemical was proportional to its concentration.

The fact that roots of some plants respond to treatment with 2, 4-dichlorophenoxyacetic acid (5), suggested that the potency of

Fig. 2. (No. 2) Reduction in growth of tops and roots from rhizomes of quackgrass treated with 100 p.p.m. isopropylphenylcarbamate; (No. 4) untreated.

TABLE 2—*Effect of isopropylphenylcarbamate and 2, 4-dichlorophenoxyacetic acid, in equal amounts, upon rhizomes of quackgrass as indicated by the number of shoots appearing 8 to 40 days after treatment.*

Concentrations (parts per million)		Number of shoots present at indicated number of days following treatment								
2, 4-D	IPC *	8	11	14	18	23	25	29	35	40
100	100	0	0	0	14	26	34	38	54	77
200	200	0	0	0	0	6	6	12	22	38
300	300	2	2	2	6	6	10	10	18	26
400	400	0	0	0	0	0	2	6	10	12
500	500	0	0	0	0	0	2	2	2	6
600	600	0	0	0	0	2	2	2	4	10
700	700	0	0	0	0	0	0	0	2	6
800	800	0	0	0	0	0	0	0	0	2
900	900	0	0	0	0	0	0	0	0	0
1000	1000	0	0	0	0	0	0	0	0	0
Control		10	54	82	94	102	102	106	118	126

*Isopropylphenylcarbamate.

isopropylphenylcarbamate might be increased by combining the two chemicals. Ten solutions were prepared containing equal amounts of each chemical, and ranging from 100 to 1,000 p.p.m. of each. Treatment consisted in dipping the rhizomes in the solution and planting them in flats in the greenhouse. The combination of these chemicals was not so effective in limiting regeneration of the rhizomes as was isopropylphenylcarbamate alone (Tables 1 and 2).

In another test isopropylphenylcarbamate in aqueous solution was thoroughly mixed with soil into which quackgrass rhizomes were subsequently planted. One liter of solution was used per flat at concentrations of 500 and 1,000 p.p.m. Fifty rhizomes, 24 centimeters in length, were planted in each flat. No new shoots developed in the treated flats, while in the control flats a number of shoots appeared after two weeks. Although the growth of quackgrass was eliminated, many seeds of broad-leaved weeds such as lambs-quarters, *Chenopodium album;* thistle, *Cirsium arvense;* ragweed, *Ambrosia elatior;* and clover, *Trifolium repens,* germinated and the plants grew normally even when the chemical was thoroughly mixed with soil (Fig. 3).

Since the concentration applied in the preceding experiment resulted in complete killing of the quackgrass, additional trials were run at lower concentrations (100, 200, 400, and 600 p.p.m.) to determine the range of effectiveness. One-half liter of the various concentrations was stirred into individual flats of soil, which were then

Fig. 3. The soil in the upper flat was treated with one-half liter of a solution containing isopropylphenylcarbamate at 200 p.p.m. before planting rhizomes of quackgrass. Four weeks after treatment no new shoots of grass had appeared, but many seeds of broad-leaved weeds had germinated and were growing normally. The lower flat was left untreated as a check.

TABLE 3—*Effect of isopropylphenylcarbamate applied in aqueous solution at the rate of 500 cc. per flat upon rhizomes of quackgrass as indicated by the number of shoots appearing 8 to 40 days after treatment.*

Concentrations (parts per million)	Number of shoots present at indicated number of days following treatment								
	8	11	14	18	23	25	28	35	40
100	3	5	6	7	7	7	8	8	8
200	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0
600	0	0	0	0	0	0	0	0	0
Control	35	67	96	107	107	112	112	113	113

planted with 50 rhizomes. Only a few spears of grass appeared from treatments of 100 p.p.m., whereas no regeneration appeared in treatments of 200, 400, and 600 p.p.m., and the control flats showed the usual luxuriant growth (Table 3 and Fig. 4).

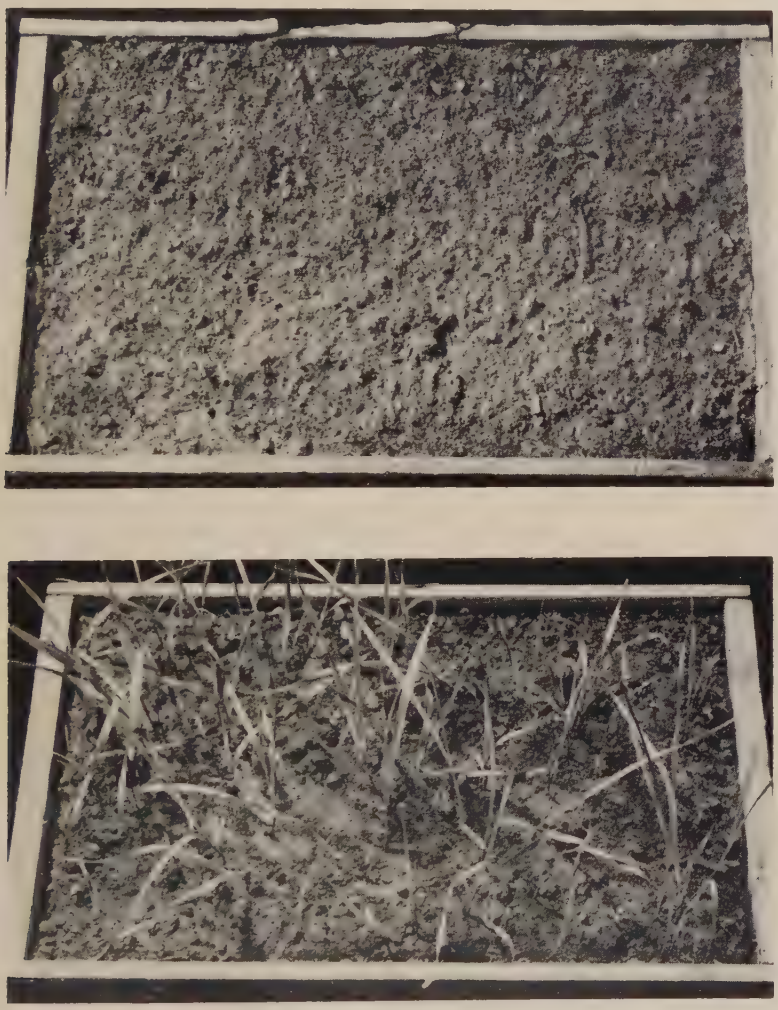

Fig. 4. The effect of isopropylphenylcarbamate as a soil treatment on rhizomes of quackgrass. The soil in the upper flat was treated with one-half liter of a 200 p.p.m. solution; lower flat was left untreated. Picture taken 2 weeks after treatment.

SUMMARY

These preliminary studies indicate the effectiveness of isopropylphenylcarbamate in destroying rhizomes of quackgrass. The leaves of this plant were injured little if at all when sprayed with 1,000 p.p.m. of this compound, but the rhizomes, on the other hand, failed entirely to regenerate new shoots when treated with concentrations above 500 p.p.m., and very few leaves appeared with applications as low as 100 p.p.m. Isopropylphenylcarbamate is a selective herbicide; it is lethal to rhizomes of quackgrass but apparently does not harm many other plants and germinating seeds. This suggests the possibility of using it in conjunction with summer fallowing and with cultivation of row crops—cultivating the rhizomes to the surface and spraying during the same operation so as to bring the material into direct contact with as many rhizomes as possible.

The results obtained by the application of isopropylphenylcarbamate to rhizomes of quackgrass under greenhouse trials warrant further testing under field conditions.

ACKNOWLEDGMENT

Acknowledgment is made of some of the chemicals used in this study that were provided by the Dow Chemical Company of Midland, Michigan, and the Pittsburgh Plate Glass Company, Columbia Chemical Division, Pittsburgh, Pennsylvania.

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INFRARED HEAT BULBS FOR DRYING GLADIOLUS CORMS

By PAUL R. KRONE
SECTION OF HORTICULTURE

THE USE of infrared heat bulbs would seem to offer some possibility for the rapid drying and curing of gladiolus corms and certain bulbs when heated storage or curing rooms are not available. They would probably not be practical for the large grower who already has other facilities but for those who grow 25 to 30 or perhaps even 50 bushels these bulbs offer a distinct possibility.

To determine their effectiveness, six trays of gladiolus corms, each containing 18 pounds of corms of the variety Maid of Orleans, were selected. They had been dug 3 days prior to the treatment and washed with a hose and allowed to drain and air dry for 2 days in screen bottom trays.

Three of the trays were taken into a laboratory where the temperature ran approximately 75° F. and three were placed in an unheated garage where the temperature ran 45-55° F.

An 8-inch fan was placed over one tray in the garage and over another in the laboratory. A 250-watt infrared bulb was mounted 3 feet above the second tray in each location, and the third tray in each case was left for a check.

In the 75-degree room the weight of the bulbs in the tray on which the light was used was decreased by 16 percent in 24 hours. Approximately the same decrease was obtained with the fan. This compared with a decrease of less than 1 percent when neither was used.

In the 45-55-degree temperature the decrease in weight amounted to approximately 6 percent while the decrease in weight in the check lot was negligible.

The decrease in weight could be considered to be moisture loss. The corms had dried out very noticeably and could be cleaned much more easily than those in the check trays.

Although one bulb had been used to one 20-by-36-inch tray, a

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check of the temperatures indicated that probably three or possibly four trays could be treated at one time with one bulb by placing it approximately 4 feet above them. The rate of drying would be slower but the cost of installation would be greatly reduced.

In the garage, when the inside temperature was 55° F., it was 80° at a distance of 20 inches directly in front of the bulb; 72° at 36 inches; 66° at 48 inches; and 64° at 60 inches.

Casual observation indicates, however, that the drying power of this infrared ray bulb might not necessarily be accurately measured by the temperature as read on a thermometer. This would be indicated by the more rapid moisture loss at a thermometer reading of 72° under the light in the garage than at 75° F. in the control tray in the laboratory.

Although the results under these conditions were nearly identical for the light and the fan, these tests were run on dry days in dry rooms. It is believed that in a highly humid atmosphere the bulb might have some advantage.

USE OF DDT IN THE CONTROL OF THE MINT FLEA BEETLE[1]

By RAY HUTSON, ELVA L. JONES and ERWIN J. BENNE
SECTIONS OF ENTOMOLOGY AND CHEMISTRY

THE MINT FLEA BEETLE is one of the serious insect pests of peppermint and spearmint plants grown in Michigan, and is probably more responsible for stunting or killing cultivated mint plants and for lowering oil yields than any other single factor (1, 2, 3). This insect can be controlled by the use of arsenical poisons (2, 3); however, since the advent of DDT as an insecticide, Hutson (4) has found that a single application of 40 pounds of a 3-percent DDT preparation per acre, applied as a dust at the proper time, is sufficient for very effective control of this pest.

DDT is a toxic substance, however, and the question arose as to whether appreciable quantities might pass over with the oil at the time it is steam-distilled from the plants and thus concentrate in the product. Therefore, it seemed desirable to determine how much of the insecticide was present in peppermint oil distilled from treated plants.

Attempts were made to answer this question by subjecting peppermint plants dusted with DDT to steam distillation on a laboratory scale. The amounts of oil obtained were so small, however, that the analytical results were inconclusive. This was true in part, because substances present in the oil interfered with the colorimetric xanthydrol-potassium hydroxide-pyridine method of Stiff and Castillo (5), and it was necessary to resort to the use of the dehydrohalogenation method of Gunther (6). The latter method is less sensitive than the former and requires a larger sample.

Because of the need for larger samples of oil as well as the desirability of working with plants subjected to field conditions, officials of the A. M. Todd Company of Mentha, Michigan, agreed to cooperate

[1]This study was supported in part by a grant-in-aid from the Michigan Chemical Company of St. Louis, Michigan.

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with the problem. A plot of peppermint plants was dusted with DDT (3%, 40 pounds per acre) and the crop was steam-distilled separately. A period of about 3 weeks elapsed between dusting and distillation. Duplicate samples of the oil obtained were analyzed by three different analysts, using the method of Gunther (6), with the results given below.

Analyst	DDT determined in: Sample 1	Sample 2
A	0	0
B	0	0
C	trace	trace

Thus, it appears that DDT was not present in these samples in amounts that could be evaluated by this method.

In an effort to investigate further the likelihood of DDT distilling over with oil during its separation from mint plants, samples of DDT were subjected to steam distillation, both alone and in the presence of peppermint oil. In each case steam distillation was continued for 30 minutes. Suitable portions of the distilled oil were analyzed for DDT by the method of Gunther (6). In cases where no peppermint oil was present, the entire aqueous distillate was extracted with benzene, and suitable aliquots of the benzene extract were analyzed for DDT by the same method. A summary of the amounts of DDT and peppermint oil used and the DDT that steam-distilled are given below:

Contents of flask at the beginning of distillation		After 30 minutes of distillation	
gm. of technical DDT	ml. of peppermint oil	% of DDT in distilled oil	% of DDT in aqueous distillate
5	20	0.52	.....
5	0	.....	0.95

These results indicate that only a small percentage of the DDT present was steam-distilled during a 30-minute period. It is possible that these results indicate more DDT than was actually steam-distilled, since any chloride-bearing impurity, which was present in the technical DDT and subject to steam distillation and hydrolysis in alcoholic KOH solution would be evaluated as DDT by the method used.

Application of this information to the question of whether dangerous quantities of DDT could be present in mint oil from treated plants is of interest. Assuming an application of 40 pounds of a 3-percent DDT preparation per acre, only 1.2 pounds of actual DDT would be involved. Moreover, since much of the dust would never lodge

on the plants and some of that which did would be dislodged by wind and rain before harvest, it would seem improbable that more than half this amount would be present on the crop at harvest time. Assuming further that only 0.5 percent of the DDT present passed over and collected in the oil during the steam distillation process, then only three-thousandths of a pound of the insecticide would be present in the total yield of oil from an acre. In the case of a yield of 40 pounds per acre this would amount to only seventy-five millionths of a pound of DDT per pound of oil.

Very small amounts of mint oils are contained in flavored materials. For example, although 1 pound of peppermint oil is added to 100 pounds of gum, this amount will make 15,000 sticks of ordinary size (7). Consequently, 1 stick would contain sixty-six millionths of a pound of the oil. On the assumption that seventy-five millionths of a pound of DDT was present in the pound of oil used, then each stick of gum would contain only five billionths of a pound of DDT. Since the quantity of oil used in flavoring toothpaste, candy, etc., and as medicine, would presumably be similar in magnitude to that used in gum, the amounts of DDT in such products would likewise be extremely small.

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PREPARATION, UTILIZATION, AND VITAMINE CONCENTRATIONS OF THE BURBOT,

Lota lota maculosa (Lesueur)

By PETER I. TACK, RUTH INGALLS, JESSIE FINLEY KLOCKE, HELEN BAEDER, DENA C. CEDERQUIST, ELIZABETH MUSSER and MARGARET A. OHLSON

With the technical assistance of RUTH NITCHALS, JOAN PLUMMER, MARGUERITE JACKSON, VIRGINIA BUCK, BARBARA D. VAN PELT, DORA McKIBBEN WILLIAMS and LESTER F. WOLTERINK.

SECTIONS OF ZOOLOGY AND HOME ECONOMICS (FOODS AND NUTRITION)[1]

THE BURBOT is a little-known fish that dwells in considerable quantities, in the deeper regions of the Great Lakes. It is a close relative of the codfish of the Atlantic Ocean, and they have many things in common. It has a large-sized liver in which it stores vitamin rich oils. The burbot also has a firm-textured, white flesh which yields fillets singularly free from bones. The flesh is free from oils and, therefore, can be used in low-calorie, low-fat diets. This fish, however, is not attractive in appearance and many people, for no other reason, refuse to eat it.

At present there is little or no market for burbot. Fishermen take it in their nets and handle it, but are not able to realize a return for the effort. At the same time, the potential consumer is being denied a palatable and nutitious source of food. It is hoped that the information included in this report may induce wider utilization of this neglected species.

HANDLING, PREPARATION AND COOKING

Fish were obtained at various times of the year from May 1944 through May 1946 at Frankfort, Rogers City, AuGres, Leland and South Haven, Michigan. The usual commercial procedure of packing and shipping the fish in cracked ice in wooden boxes was used. The

[1]The authors are indebted to the Fish Division of the Michigan Department of Conservation for supplying the burbot that were used in the investigation reported in this article.

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fish were dressed and filleted immediately upon arrival and records kept of the yield of edible fillet, liver and liver oil. Samples were taken fresh for cooking and palatability tests. Dressed fillets were frozen and kept in frozen storage until they could be analyzed, since it has been found that freezing for a period of from 2½ to 3 months does not significantly affect the content of the vitamins studied (Klocke *et al.*, 1946).

The flesh of this fish is firm and white and may be utilized either as fillets or as steaks. The smaller fish, that is, those under 4 pounds, are better prepared as fillets, since they make small steaks. There are further advantages of utilizing the flesh as a fillet. The filleting process, if carefully done, eliminates all bones. If carelessly or hurriedly done, the ends of the ribs frequently are cut off and remain on the fillet. Since the small ends of the ribs may be troublesome, care should be exercised to remove them completely. The proportion of edible flesh was determined for 51 fishes and, as fillets, averaged 31 percent of the total weight.

Burbot should be used soon after purchase or placed in a covered container and stored under refrigeration.

Burbot was cooked in a variety of attractive ways. Recipes have been published by the Michigan Agricultural Experiment Station.[1] When cooked, the flesh is white and firm and has few bones. A panel of judges considered the flavor, color, texture and odor of the cooked fish to be excellent. The cooked burbot flesh has a mild flavor, and a sauce or a generous amount of seasoning is recommended to make it tasty. When baked or broiled, basting with a sauce or fat will prevent dryness.

Burbot's flaky texture and mild flavor make it desirable in many casserole and mixed dishes. When steamed and flaked, it may be used in chowder, in cream sauces, salads or mixed with vegetables or other foods. It holds its shape in souffles and casseroles and is very acceptable. Because of its mild flavor, a larger proportion of fish should be used in the recipe or the fish flavor is lost. If combined with a starch, such as rice or a macaroni, the amount of starchy filler may be reduced.

[1]Experiment Station Folder 6, ESF—Fish Recipes, Burbot. A copy may be obtained free by addressing a postcard request to the Bulletin Office, Department of Public Relations, Michigan State College, East Lansing.

RIBOFLAVIN, THIAMINE AND NIACIN IN RAW AND COOKED BURBOT

One-half of the skinned and filleted fish was cut crosswise into six equal sections. Three sections, one from each end and one from the middle, were taken as the sample. For comparison between raw and cooked fish, the opposite three sections of the same half fish were used for the cooked sample. The canned fish came from the same lot as the fresh though the fresh samples of the same fish were not analyzed.

Baking was done in a pre-heated oven at 350° for 15 minutes. The fish was placed on a heavy waxed paper to prevent loss of drippings. Fish and drippings were analyzed together. Fish to be pan-fried were placed in an iron skillet with a small amount of hydrogenated vegetable fat. Each piece was fried over a low flame for 3 to 4 minutes on each side and the entire contents of the pan were analyzed.

Three canning methods were used. For the first lot, the burbot fillets were cut in pieces the length of the container, soaked in brine

TABLE 1—*Riboflavin, thiamine and niacin in raw and cooked burbot.*

	Riboflavin			Thiamine			Niacin			
	Number of samples	Fresh weight	Dry weight	Number of samples	Fresh weight	Dry weight	Number of samples	Fresh weight	Dry weight	Per-cent solids
Raw, all samples	17	1.418	7.847	34	3.063	16.951	11	15.87	87.3	18.07
Mg. per gm		±0.24			±0.734			±3.45		
Baked mg. per gm	7	1.181	5.455	7	2.4321	11.233	7	8.84	40.73	21.65
Same samples raw		1.516	8.390		2.761	15.279		8.8	48.67	
Percent retention		81			86			98		
Fried mg. per gm	7	2.263	4.346	7	5.371	10.154	7	37.4	73.4	49.95
Same samples raw		1.084	5.138		4.043	21.315		16.6	78.4	20.33
Percent retention			85			48			95	
Canned mg. per gm. total	3	1.997		3	0.866	7.400				
Solids										
Liquids										
Percent retention						43.7				
Mg. per 100 gm. fish		0.1418	0.7847		0.3063	1.6951		1.587	8.73	
Percent days requirement (1)										
Fried			5		10			10		
Baked			7		18			10		

(1) Based on food needs of an adult man.

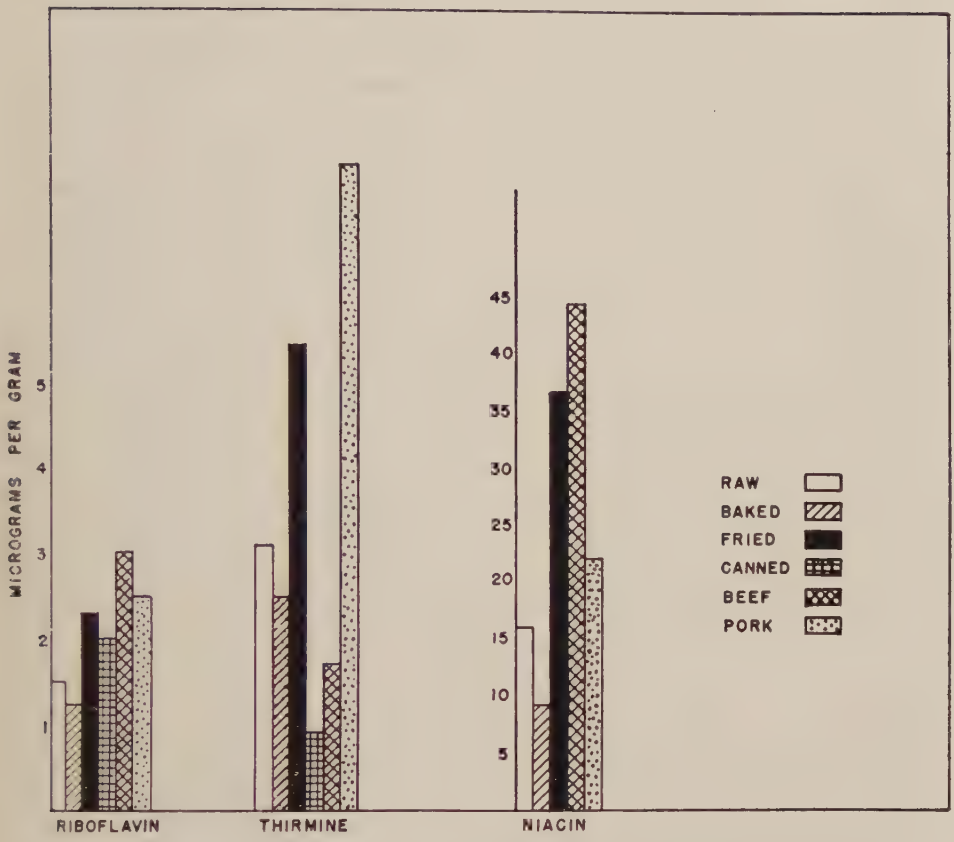

Fig. 1. Riboflavin, thiamine and niacin in raw and cooked burbot, cooked pork and beef (micrograms per gram moist weight).

(1 cup salt to 1 gallon water) for one hour. The fish was then drained, packed in hot containers, submerged, open, in a kettle of hot brine (½ cup salt to 1 gallon water), brought to the boiling point and boiled 15 minutes. The jars were then removed and drained 5 minutes. The second method used a saturated salt solution or 2 cups salt to 1 gallon water. In this method the fish were soaked in the saturated salt solution for 30 minutes and then packed in hot jars. In the third method, burbot fillets were packed directly in the hot jars and 1 teaspoon salt added to each jar. All canned fish were sealed and processed at 10 pounds pressure for 70 minutes.

The fish samples to be analyzed for vitamins were macerated in a Waring Blendor. Analyses for riboflavin, thiamine and niacin were

made by accepted methods which have been described in detail elsewhere (Conner and Straub, 1941, Klocke, *et al.*, 1946, 1947).

Fresh burbot was found to contain an average of 1.418 micrograms per gram riboflavin, 3.063 micrograms per gram thiamine and 15.8 micrograms per gram niacin (Table 1). This is about half the amount of riboflavin (Cover *et al.*, 1944) and one-fourth the amount of niacin in beefsteak (Fig. 1). However, it is two and one-half times the amount of thiamine found in beef and nearly half the amount found in roast pork (Sweigert *et al.*, 1944) which is one of the best sources of thiamine.

When calculated on the basis of dry weight, 81 percent of the riboflavin, 86 percent of the thiamine and 99 percent of the niacin are retained after baking. Cover and others (1944) found 77 and 83 percent of the riboflavin, 69 and 75 percent of the thiamine and 79 and 75 percent of the niacin retained in well-done and rare beef roasts, respectively. The short cooking time and the fact that there were no losses in the drippings may account for the higher retention of thiamine and niacin in fish. The range in the retention of riboflavin in baked fish varied from 78 to 84 percent in several lots of fish, which is similar to the amount retained in beef roast. There was a retention of 85 percent of the riboflavin and 95 percent of the niacin after pan frying. The apparent increase of riboflavin, thiamine and niacin in fried fish (Fig. 1) was due to loss of moisture during cooking. Canning by any of the methods apparently caused very little loss of riboflavin or niacin but two-thirds of the thiamine was destroyed. However, the number of samples tested was small.

WEIGHT AND OIL CONTENT OF BURBOT LIVERS

The liver weight of the burbot is a variable portion of the total weight. Individual values vary from a low of 2.6 percent of the

TABLE 2—*Seasonal variation of liver weight in the burbot.*

Date caught	Locality	Number	Average liver weight as percent of total
May 5, 1944	Frankfort, Michigan	14	14.4
Nov. 30, 1944	Frankfort, Michigan	16	13.4
Dec. 4, 1944	Rogers City, Michigan	20	10.3
Dec. 26, 1944	Frankfort, Michigan	28	10.1
Nov. 27, 1945	AuGres, Michigan	24	7.3
Dec. 15, 1945	Leland, Michigan	31	10.7
Mar. 12, 1946	South Haven, Michigan	15	14.1
May 8, 1946	Frankfort, Michigan	30	12.6

TABLE 3—*The oil content of burbot livers.*

Date caught	Locality	No. of fish	Mean liver weight in gms.	Range in gms.	Percentage of oil	
					Mean	Range
Dec. 15, 1945	Leland, Michigan	10	139.6	74–224	37.1	28.7–52.4
Mar. 12, 1946	South Haven, Michigan	10	293.8	187–547	43.6	38.6–52.2
May 8, 1946	Frankfort, Michigan	12	183.5	78–338	41.6	28.2–55.5
May 8, 1946	Frankfort, Michigan	11	185.1	125–258	41.9	30.7–49.5

total weight to a high of 22.6 percent. The liver weight varies with the season, the winter values being lower than summer values (Table 2).

The liver weight also appears to be related to the size of the fish. The larger fish tend to have a slightly higher percentage of the total weight as liver.

The livers of all the fish contained a high proportion of oil, though here again, the variation was wide. The percentage of oil by weight ranged from a low of 28.7 to a high of 55.5. The average amount of oil and the range for several samples are presented in Table 3.

The larger fish seemed to have slightly more oil in the liver than the smaller ones.

EXTRACTION AND VITAMIN D POTENCY OF LIVER OIL

The oil can be extracted rather simply in a pressure cooker, or other steam cooking retort. It is desirable to cook the livers in steam so that oxygen may be excluded to prevent a loss of vitamins, which would lower the value of the oil. Cooking ruptures the cells and releases the oil. If the livers are covered with water, the oil floats to the top and can be decanted off.

In these studies the livers were cooked in a steam retort at 15 pounds pressure for a period of 30 minutes. The oil and other liquid were then poured into a glass container and placed in a refrigerator where the temperature was held near 32° F. for about 24 hours. During this time the oil and water separated and the higher melting point fats (sterols) solidified. The oil was then decanted and filtered through a heavy creped filter paper of medium texture. This removed the sterols and solids and left a clear pale yellow oil of a pleasant, mild odor and flavor.

The vitamin D assay method as outlined in the U. S. Pharmacopeia XII (1942) was used, with minor modifications, to determine the vitamin D potency of five samples of burbot liver oil.

Weanling rats from the stock colony of the Michigan State College Department of Chemistry were placed on a diet of the following composition:

Yellow corn meal	69%
Wheat gluten	25%
Brewer's yeast	2%
$CaCo_3$	3%
Na Cl	1%

At the end of three weeks, the animals showed marked signs of gross rickets. The rachitic animals were separated into groups and fed one of the following diets for six days:

(a) Rachitogenic diet.

(b) Rachitogenic diet plus weighed amounts of standard cod liver oil.

(c) Rachitogenic diet plus weighed amounts of burbot liver oil.

On the eighth day the animals were sacrificed and the degree of healing as determined by the line test was observed.

Five samples of burbot liver oil were studied. Early samples of the burbot oil contained approximately 230 international units of vitamin D per gram. Later samples, which had been prepared under more carefully controlled conditions, contained 345 to 460 I. U. per gram. The vitamin D potency of some common fish liver oils is shown in Table 4. Results of this study indicate that burbot liver oil has a higher vitamin D potency than the reference cod liver oil. Although not so high in vitamin D potency as certain other fish liver oils, the low cost at which burbot liver oil could be produced suggests that it might be a valuable product for poultry and animal feeds.

Other possible uses of burbot liver oil are in tanning leather. Samples of the oil were supplied to a local taxidermist who experimented on rabbit skins and on burbot skins and found it to be a useful oil for tanning purposes.

TABLE 4—*Vitamin D potency of certain fish liver oils.*

Source of oil	I. U. of vitamin D per gram
Cod liver oil (McCollum et al, 1939)	85–250
Halibut liver oil (McCollum et al, 1939)	1200
Herring (McCollum et al, 1939)	1000
Sardine (McCollum et al, 1939)	800
Tuna (bluefin) (McCollum et al, 1939)	40,000
Burbot liver oil (Branion, 1934)	equals standard cod liver oil
Burbot liver oil (this study)	230–460

SUMMARY AND CONCLUSIONS

The flesh of burbot, a little-known fish of the Great Lakes, which is handled by fishermen in the nets, has been found to produce fillets of good color and texture, relatively free of bones. Prompt handling and refrigeration are necessary to preserve maximum quality. The cooked fillet has a mild flavor and high palatability which makes it suitable for a variety of dishes.

An average serving of burbot furnishes 6 to 8 percent of the day's requirements of riboflavin, 10 to 18 percent of thiamine and 10 percent of niacin. These figures consider cooking losses. Burbot may be considered an excellent source of thiamine and a fair source of riboflavin and niacin.

Burbot livers contain from 28.7 to 55.5 percent of clear, light yellow oil of mild odor and flavor. The concentration of vitamin D in properly extracted burbot liver oil may be several times higher than that of standard cod liver oil.

It is concluded that both the flesh and liver oil of the burbot are potential market products which should provide an additional source of revenue to the fishing industry without greatly increasing operating costs.

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VALUE OF RED CLOVER IN A ROTATION

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THE VALUE OF CLOVER as a soil-building crop has long been recognized by farmers. Experiments conducted by the Soil Science Section at East Lansing afford an opportunity to evaluate to a certain extent this beneficial effect of clover on the crops that follow.

In 1931 a rotation experiment was established on Hillsdale sandy loam soil on the College Farm to study the effect of fertilizers applied in different ways. The rotation consisted of corn, barley, wheat and clover. In addition to the fertilizer treatments each of the four blocks included seven untreated or check plots. In 1934 another rotation experiment was established in the same field on the same type of soil. This rotation consisted of corn, barley and wheat without the clover. Each of these three blocks contained eight untreated plots. The untreated plots in the two experiments were handled the same except that in one they grew clover and in the other they did not.

TABLE 1—*Effect of clover on the yields of other crops in a rotation.*

Eleven-year average annual acre yields

	Corn		Barley		Wheat		Clover	Total
	Grain bu.	Stover lb.	Grain bu.	Straw lb.	Grain bu.	Straw lb.	Hay lb.	per rotation
Four-year rotation with clover	37.09	3,420	21.86	1,306	25.62	2,289	*1,809	.....
Three-year rotation without clover	30.15	2,667	14.60	934	23.89	2,154	.....	.....
Increase due to clover	6.94	753	7.26	372	1.73	135	.....	.....
Value of increases	**$6.04	$1.32	$5.66	$0.65	$1.92	$0.24	.....	$15.83
Value of increases	***10.13	1.88	9.87	0.93	3.20	0.34	.....	26.35

*During the 11-year period covered in this report clover failed three times owing to drought. Otherwise, the average annual yield of clover would have been larger, as the years of failure were averaged in with the others. The increase in yields of other crops due to clover might also have been greater.

**Based on average prices for the 11-year period. Corn $0.87; barley $0.78 and wheat $1.11 per bushel. Straw and stover $3.50 per ton. Grain prices taken from the report of the government agricultural statistician's office, Lansing, Mich. Straw and stover price estimated.

***Based on 1946 prices. Corn $1.46; barley $1.36 and wheat $1.85 per bushel. Straw and stover $5.00 per ton. Source of prices—same as in previous footnote.

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On all plots growing clover the second crop was plowed under in the spring for corn. In the data presented in Table 1 the average yield of each crop for a period of 11 years from the untreated plots of the two experiments are compared. That gives the average yields from 77 harvests of each crop from untreated plots in the rotation including clover to be compared with the average yields from 88 harvests of each crop from untreated plots in the rotation not including clover.

A glance at the data shows an increase of 6.94 bushels of corn and 753 pounds of stover, an increase of 7.26 bushels of barley and 372 pounds of barley straw, and an increase of 1.73 bushels of wheat and 135 pounds of wheat straw from the rotation including clover. These increases are assumed to be due to the clover. In addition to the increased yields of other crops, there was an average annual acre yield of 1,809 pounds of clover. The values of these increases are also given in Table 1.

Three clover failures due to drought occurred during the period covered by this report. The 1,809 pounds of clover represent the total weight for the eight years when clover was produced divided by 11, or the total number of years in the period. Had clover been produced all 11 years the average yield would have been larger and, no doubt, the yields of other crops in the rotation would also have been larger.

The increased yields of corn and barley due to clover in the rotation are very substantial. The smaller increase in the yield of wheat might be partly explained by the fact that wheat comes farther away in the rotation from the clover sod than do the other crops, at which time the effect of the clover is largely dissipated.

These increases in crop yields, in a large measure, resulted from the nitrogen in the clover which was taken from the air by the clover plant and incorporated into the soil when the clover sod was plowed under.

All during the recent war considerably more commercial nitrogen was allocated by the federal government to southern agriculture than to Michigan which boasts of maintaining a large acreage of legumes, such as clovers and alfalfa, as well as feeding a large number of livestock. At present the fertilizer industry is handicapped by a shortage of commercial nitrogen. This shortage in Michigan is alleviated by maintaining a large acreage of legumes.

In making the comparisons presented here it was necessary to use unfertilized plots in order to eliminate factors that would make comparison difficult or impossible. To evaluate clover as a soil-building crop, however, one should remember that clover obtains all its nutrients from the soil except part of the nitrogen, which it takes from the air. Furthermore clover removes more potash, lime and phosphoric acid from the soil than do most grain crops. To be a soil-building crop, therefore, the clover should be well fertilized with phosphate and potash. The increased yield of crops following the clover would undoubtedly have been much greater if the clover had been well fertilized.

MAXIMUM UTILIZATION OF ROUGHAGE AND PASTURE BY STEERS: SECOND EXPERIMENT

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The second experiment to study methods and results in wintering, grazing and fattening beef calves was started at Michigan State College in December 1945. The results are presented in the following discussion, along with brief tables. Results of the first test were published in the Michigan Agricultural Experiment Station Quarterly Bulletin, Volume 28, No. 4, May 1946, and a third test now in progress was started January 15, 1947.

Four uniform lots of 12 calves each were fed different winter rations from December 27 to June 4, and at that time were re-allotted into six lots of eight steers each for further tests in grazing and fattening. The calves were good to choice Herefords, nine of which were raised at the Lake City Branch Station, and the remaining calves, purchased locally, were said to have originated in Montana.

PLAN AND PROCEDURE

Calves in lots A and B were fed so as to gain at a similar rate during the winter, and their gain was distinctly more than the gain in lots C and D. In June there was a difference in flesh and finish, as well as a difference in weight of about 80 pounds per head.

Four calves from Lot A and four from Lot B constituted Lot 1 for the grazing and fattening periods, while four calves from Lot C and four from Lot D made up Lot 4. These calves received corn and soybean meal during the entire pasture period, June 4 to September 11 and, with silage and hay added, thereafter were continued on feed until a "top good" finish was attained.

The four remaining lots were made up in a similar manner, lots 2 and 5 being grazed for 58 days before receiving grain feed, and lots 3 and 6 being grazed for 87 days before receiving grain.

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Cattle were weighed each 14 days while in the feed-lots and approximately each 30 days while on pasture. All cattle were removed from pasture September 11 as prolonged drought prevented additional growth for fall grazing.

The pasture was largely smooth brome grass, with some other grass mixture and a limited mixture of alfalfa. The cattle in lots 3 and 6 grazed on a rather light second crop of blossoming red clover and alfalfa during the last 34 days when other pasture was exhausted.

RESULTS OF WINTERING RATIONS

As may be seen in Table 1, the calves in lots A and B made similar gains of 1.6 pounds daily. Calves in Lot B received a full feed of silage, with hay *ad libitum*, soybean meal for protein, and 3 pounds of corn the last 6 weeks. Those in Lot A received neither silage nor soybean meal, but ate considerably more hay and required 5.7 pounds of corn daily to gain as rapidly as those in Lot B.

At prices charged for feeds as indicated in the footnote to Table 1, gains were $3.64 cheaper per 100 pounds for the silage-fed calves in Lot B than for the hay and corn-fed calves in Lot A. These results were rather similar to those in the previous experiment.

Calves in Lot D, fed liberally on corn silage and hay, gained about a pound a day, which was slightly faster than in the previous year's test. The cost of gain was $12.63 per 100 pounds, compared with $15 in the first experiment, and fell between the costs for lots A and B.

The Lot C calves gained 1.2 pounds daily on a ration of 2 pounds of corn and 12.3 pounds of hay, at a cost of $13.88 per 100 pounds. The year before they gained 0.95 pounds on a similar ration at a cost of $18.02 per 100 pounds.

The only explanation of the greater gain and lower cost in this second experiment, and of the greater gain as compared with Lot D, is possibly due to a better quality hay. It was first cutting from a second-year hay crop of rather fine leafy alfalfa with light brome mixture. It was cut in early bloom and baled from the windrow, but was thoroughly soaked from heavy rain after baling. Considerable white mold resulted but the calves ate it readily.

RESULTS IN GRAZING

Steers in the first three lots were about 80 pounds heavier than those in the last three lots when they went to pasture June 4, 1946. Steers in lots 1 and 4 received grain throughout the summer, and thus

TABLE 1—*Wintering, grazing and fattening calves—1945-46.*

	Wintering phase			
12 steers per lot Dec. 27—June 4—159 days	Lot A	Lot B	Lot C	Lot D
Initial weight	411	407	409	409
Daily gain	1.62	1.57	1.21	.98
Daily ration:				
Corn, ground	5.7	1.1	2.	.....
Soybean meal	.....	1.2	.....	.....
Corn silage	.....	23.9	.....	20.4
Hay, mixed	11.8	4.0	12.3	4.8
*Feed cost 100 pounds gain	$15.20	$11.56	$13.88	$12.63

	Grass-alone phase					
	From A and B above			From C and D above		
8 steers per lot from June 4	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Days, grass only	0	58	87	0	58	87
Initial weight	664	659	663	582	582	587
Daily gain	fed / grain	1.03	.75	fed / grain	1.27	1.04
*Feed cost 100 pounds gain	.....	$5.81	$7.95	.....	$4.72	$5.76

	Grain feeding phase					
All cattle removed from pasture Sept. 11						
Date grain started	June 4	Aug. 1	Aug. 30	June 4	Aug. 1	Aug. 30
Date last fed	Sept. 25	Nov. 10	Nov. 10	Nov. 10	Dec. 30	Dec. 29
Days on feed	113	101	72	159	151	121
Daily gain	1.89	1.83	2.46	1.94	1.96	2.44
Final weight	878	903	905	891	951	973
Daily ration:						
Corn, ground	8.0	9.1	9.0	8.6	9.8	9.9
Soybean meal	1.1	1.4	1.4	1.2	1.6	1.7
Corn silage (after Sept. 11)	9.7	20.0	26.6	13.3	14.0	34.2
Hay (after Sept. 11)	3.3	3.0	4.3	3.3	2.6	5.0
*Feed cost 100 pounds gain	$14.12	$17.96	$15.01	$15.32	$18.05	$16.16

	Summary					
*Necessary selling price to pay for calf and feeds	$13.85	$14.09	$13.58	$14.32	$14.40	$13.75
Dressing, percent	58	56	57	58	59.5	59.5
Sale value basis $16 for 60% dress	$15.40	$14.80	$15.10	$15.40	$15.85	$15.85
*Return per head above calf and feed cost	$13.58	$ 6.36	$13.75	$ 9.66	$13.76	$20.45

*Prices as in previous experiment: Feed-lot calf cost 14 cents, corn $1.26 bu. or $45 ton, soybean meal $60, silage $7.50, hay $20 per ton. Pasture only $1.80, with grain $1.50, per month.

there was no grazing period without grain. As was true in 1945, the lighter and thinner steers in lots 5 and 6 made faster and cheaper gains than the steers in lots 2 and 3. Also, those grazed for 58 days without grain, in lots 2 and 5, made faster and cheaper gains than those grazed for 87 days, in lots 3 and 6.

The steers in lots 3 and 6 made low gains during August, although grazing on second cutting red clover and alfalfa in bloom. They did make very heavy gains soon after starting grain feed, and it was not apparently from conditions of weighing.

THE GRAIN FEEDING PERIOD

All cattle were removed from pasture September 11, although grain feeding was started previously in all lots on the dates shown in Table 1. The entire time when grain was fed is considered together, whether the animals were on pasture or in the barn.

Average daily rations were computed for the time each feed was actually fed, thus the amounts of silage and hay were those fed after September 11.

Steers in the first three lots, which were in better flesh in June, finished about 50 days sooner than the thinner steers in the corresponding last three lots. Cattle in these paired lots, 1 and 4, 2 and 5, 3 and 6, performed in a rather similar manner with regard to rate of gain, and also feed cost for gain.

Low costs in lots 1 and 4 are due to use of pasture at a low cost throughout the summer while on feed. Low costs in lots 3 and 6 are due to rapid gains. These two lots had a high silage ration. Whether their rapid gains were partly due to having grazed on good legumes the last 34 days is problematical.

FINANCIAL SUMMARY

Pasture and feeds were charged as indicated in table footnotes. Prices in Table 1 are the same as those used in the 1944-45 experiment. In Table 2 various price bases are used for comparison of costs.

The necessary selling price to pay for calf and feed is found by dividing those total costs by the feed-lot weight of the finished steer. The differences among lots are not great.

Three lots of steers were slaughtered in East Lansing and three lots were sold and slaughtered in Detroit. The former cattle were taken off feed the night before slaughter and shrunk weights were used to calculate dressing percentages from cold carcass weights. Those sent to Detroit shrank a similar amount from the feed-lot weights, and sale weights were used for dressing percentages.

Since a base price of $16 for steers dressing 60 percent was used last year, a similar calculation was made for comparison. The difference between necessary selling price and this sale price, times the weight per steer, gives return per head above costs for feeder calf and feed.

TABLE 2—*Costs at varying feed and cattle prices.*

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Dressing percent	58	56	57	58	59.5	59.5
Feed-lot sale value, basis $16 for 60% dress	$15.40	$14.80	$15.10	$15.40	$15.85	$15.85
Feed-lot sale value, basis $22.40 for 60% dress	21.56	20.72	21.14	21.56	22.19	22.19
(1)Necessary selling price (to pay for calf and feed at costs in Note 1)	$13.85	$14.09	$13.58	$14.32	$14.40	$13.75
(2)Necessary selling price (at costs in Note 2)	17.55	17.85	17.20	18.12	18.22	17.40
(3)Necessary selling price (at costs in Note 3)	18.45	18.75	18.10	19.02	19.12	18.30
(4)Necessary selling price (at costs in Note 4)	20.35	20.71	19.92	21.02	21.14	20.15
(5)Necessary selling price (at costs in Note 5)	21.25	21.61	20.82	21.92	22.04	21.05

(1)Prices as in previous experiment: Feed-lot calf cost $14, corn $1.26, soybean meal $60, silage $7.50, hay $20 per ton. Pasture alone $1.80, with grain $1.50, per month per head.

(2)Calf cost $18, feeds 25% above Note 1, or corn $1.575, hay $25, etc.

(4)Calf cost $20, feeds as in Note 2.

(4)Calf cost $20, feeds 50% above Note 1, or corn $1.89, hay $30, etc.

(5)Calf cost $22, feeds as in Note 4.

Steers in Lot 2, which were well wintered, grazed 58 days, and then fed 101 days, made least return. Those in Lot 4, lightly wintered, fed grain on pasture and in the barn until finished, were next low. Those in Lot 6, lightly wintered, grazed 87 days, and fed 121 days, were highest. The other three lots were similar and were mid-way between lots 2 and 6.

One comparison not shown in the tables is the effect of wintering rations A and B on final results in the first three lots. Steers wintered in Lot B cost $9.25 per head less than those wintered in Lot A, and half of the steers in lots 1, 2 and 3 came from each of these two lots.

In a similar manner the difference in wintering costs in lots C and D amounts to $2.17 per steer. These steers were equally divided among lots 4, 5 and 6.

Further comparisons have been made in Table 2 so that one can study various calf and feed costs. These necessary selling prices do not cover labor, interest or overhead charges, nor credits for manure.

An increase of $2 in a 409-pound feeder calf price can be covered with 90 cents increase in price of a 917-pound average steer. A rise in selling price of just under $2 per 100 pounds would be necessary if there occurred an increase of 31.5 cents per bushel in corn price, $5 per ton of hay, $1.875 per ton of silage, $15 per ton of soybean meal,

and 37.5 or 45 cents per month in pasture cost, depending on whether grain was fed.

Throughout this experiment, as well as the previous test, use of pasture is indicated as one method of cutting costs in growing and fattening cattle.

PEN TESTS OF RABBIT REPELLENTS

By H. A. CARDINELL and D. W. HAYNE
SECTIONS OF HORTICULTURE AND BOTANY

ORCHARD DAMAGE by cottontail rabbits[1] is a problem of long standing in Michigan. The buds, shoots, and bark of small deciduous trees normally form a portion of the animal's winter diet. When this bark happens to come from the trees of an orchardist or a nurseryman, rabbits may cause considerable financial loss. There are two methods of preventing this damage to trees—either remove the rabbits, or protect the trees. Cottontail rabbits are protected in a number of states, because of their importance as small game. In Michigan the State Department of Conservation may issue a permit allowing control of rabbits in an orchard. Removal of any excessively high population of rabbits by hunters during the open hunting season is probably the most desirable method of control, but orchardists may be reluctant to risk shotgun or other damage to young trees.

Trees may be protected from rabbits in several ways (4, 8). The entire area of a small planting may be fenced, using poultry netting of 1-inch mesh. A more common method of protection is by means of individual guards of wire mesh about each tree. These guards last for several years and supply some protection against rabbits, but only the trunks of trees can be protected. Since cottontail rabbits will reach about 2 feet above whatever snow may be drifted about the tree, wire mesh guards often do not extend high enough to furnish complete protection, and scaffold limbs may suffer damage. The same consideration applies to the somewhat less permanent tree guards of wood veneer, asphalt paper, or corn stalks.

Repellents, or protective coatings provide a third means of tree protection. The thought of coating tree trunks with some material so disagreeable that rabbits would not eat the bark apparently has appealed to the imagination of fruit growers for many years. If the variety and complexity of the formulae are any criteria, a tremendous

[1] *Sylvilagus floridanus mearnsii* (Allen).

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amount of time and energy has been spent in the compounding of rabbit repellents. Old and new farm magazines carry frequent accounts of a correspondent's faith in his own concoction.

Few records are to be found of experimental studies of rabbit repellents. Harvey (5) reported on tests using "chinchilla" rabbits and "wild" rabbits, where a solution of sulfurized oil gave satisfactory protection to trees. He also reported a number of materials giving little or no protection. Neilson (9) recorded preliminary information on experiments carried on at the Michigan Agricultural Experiment Station. Although the species of rabbit used in his tests was not recorded, cottontail rabbits are presumed to have been used. A mixture of five parts of rosin melted with one part of linseed oil was found to give protection. A second recommended formula contained rosin, fish-oil, and copper soap (copper-oleate). Both formulae required heating before application. Commercial products found to be effective were "Hood River Tree Paint" and "Tree Saver". Concerning unsatisfactory treatment, Neilson said "Sulphonated oil, both commercial and home-made, Dendrol Nursery Wax, Parapin, Tree Seal, Protex, Vultex, Nature Seal, Fish-Oil Soap, Bunny-Bane, and Barrett's Liquid Elastigum did not prove satisfactory in any of the tests." Warning was given that the effective mixtures seemed to injure sweet cherry and peach trees. Both recommended formulae required the use of an efficient heater, and in cold weather the brushing quality of the hot mixtures on the cold tree trunks was so poor as to make their use impractical. Certain growers also reported damage to fruit trees, attributed to the use of these solutions.

The present paper is a report on repellent experiments begun during the winter of 1937-38 at the Graham Horticultural Experiment Station at Grand Rapids, Michigan, and since then carried on both at the Graham Station and at the College, East Lansing. The most recent experiments here reported were conducted during the spring of 1943. The cottontail rabbits used in the tests were caught locally at the two stations. A preliminary report of this work has been issued (2).

METHODS USED

There are two general methods of conducting repellent tests. The repellent may be offered to captive rabbits in pen tests, or the repellent may be applied to plants subject to damage by rabbits at large, in field tests. There is no doubt that field tests have certain advan-

tages. Pen tests start with unnatural conditions for the rabbits, which may influence their apparent preferences; and the ultimate test of a repellent is whether it protects plants in the field. On the other hand, rabbit damage is somewhat unpredictable, making it difficult to choose an experimental field site where damage surely will take place in the absence of protection. A known state of potential plant damage can be produced in pens, and ordinarily the tests can be made far more severe than field tests, except under rare conditions. For this reason, pen tests are especially useful when a number of possible repellents must be screened to select the few most useful formulae. Pen tests should be confirmed by field trials.

The first experimental trials in this study were made in large pens containing several rabbits. Later, individual tests were made, where smaller pens, each containing a rabbit, were supplied with similar lots of treated materials. These individual pen tests also furnished information about differences among individual rabbits in food preferences.

Materials to be tested were painted onto the bark of shoots freshly cut from apple trees, and after a few hours' drying period, were exposed to the rabbits. All tested mixtures were applied by means of paint brushes. The shoots for one experiment were cut from the same tree, wherever possible, and were restricted in diameter to a range of between three-eighths and three-quarters of an inch. It was found by experiment that apple shoots smaller than three-eighths of an inch in diameter were often cut off cleanly by the rabbits, while branches larger than three-quarters of an inch were somewhat less attacked, even though untreated.

Each pen was provided with several, usually four or five, shoots covered with each mixture, as well as with similar untreated sticks of apple wood. In some of the later experiments, untreated shoots of other tree species than apple were included. The shoots being tested were held upright by a support or feeder and as many as 20 treatments were tested at one time. Data were recorded as percentage of the bark removed by the rabbits.

The experiments were planned and laid out to take advantage of the features of the "analysis of variance" methods of statistical comparison. Relatively precise comparisons between repellent mixtures or between various individual rabbits are available for study. However, strict statistical analysis of the data is not necessary for purposes

of selecting the best repellent mixtures. In general, unless the differences in effectiveness are easily apparent, the repellents being tested are considered of about the same effectiveness. By using a careful experimental design, certain otherwise uncontrollable factors influencing the rabbits can be equalized for the treatments tested.

RESULTS OF TESTS

The results of such pen trials of repellents are entirely comparative, and mean little unless certain standard comparison materials are included in each trial. The absolute amount of bark eaten from any treated shoot will depend upon the comparative acceptability to the rabbits of the other treatments available. In all the experiments, three dilutions of the rosin-ethyl-alcohol repellent (2) were included as standards, and in almost all experiments untreated sour cherry (Mahaleb) shoots were included.

The repellent mixtures tested are listed at the end of the present paper. Three classifications have been set up, according to the results of the trials. Included in Group I is any repellent as effective as the rosin-ethyl-alcohol formula, mixed two parts of rosin to one part of alcohol by weight. Group I contains only those mixtures considered to be very good. To be included in Group II, considered as "fair," or promising for use under less than extreme conditions, a mixture had to be as effective as the rosin-ethyl-alcohol formula when prepared with one part of rosin to two parts of ethyl alcohol by weight. Group III, containing the remainder of the tested materials, includes the third dilution of the rosin-ethyl-alcohol formula, one part of rosin to eight parts of ethyl alcohol, by weight. This third classification includes a number of mixtures considered as of appreciable effectiveness but useful in the field only under favorable conditions, and also includes a number of mixtures of less effectiveness, down to those apparently as acceptable as the untreated apple wood. Sour cherry bark, included in Group III, is seldom seriously damaged by cottontails in Michigan, and in pen tests it ranked near the 1-to-8 rosin-ethyl-alcohol dilution in acceptability to the rabbits.

Definite evidence of differences between rabbits in individual food preferences was found in the individual pen tests. This was especially true in the case of materials which seemed in general to have only a moderate protective ability. Against some rabbits the protection seemed very poor, while against other rabbits the protection, while

not of the best, was at least moderate. Until more is known about the extent and nature of these individual taste preferences, their existence prevents a definite statement of the value of any particular mixture. These individual differences may help to explain why there are differences in the effectiveness of various mixtures in different regions. It is known that cottontails eat a winter diet of different shrubs in various parts of the country (1, 3, 6, 7, 10, 11, 12); possibly the effectiveness of some repellents may vary correspondingly.

A rabbit in the wild state seems to choose a diet according to its own food preferences, and according to the plants available to it. Not only do individual rabbits differ in exact food preferences, but the food plants available to rabbits also change from farm to farm. Each farm has its own particular combination of trees and shrubs, including the nursery and orchard stock which the orchardist wishes to protect. The amount of food available to rabbits on any farm may vary with weather conditions, especially in winter, when some plants are covered by snow and temporarily removed as available food, while other plants are brought within a rabbit's reach by a higher snow level, as is true with the tips of branches of larger trees. It may happen that small nursery stock, always near the top of the rabbit's list of preferences, suddenly becomes the chief available food. At such times, damage may be disastrous.

From the point of view of food for rabbits, therefore, each farm and orchard is a separate situation, with a variety of plant food normally available. If these plants can be thought of as listed according to acceptability to the rabbits, then the function of a repellent is to take the protected plant from near the head of the list, and put it somewhere near the foot of the list. The quantity and variety of the other acceptable food plants may determine the severity of the orchard damage problem on that farm, and will strongly affect the success or failure of any attempt to protect by repellents.

There is a great variation in the reports of success from the use of repellent mixtures. Apparently much of the disagreement between different observers may be explained by the factors of individual rabbit food preferences, and differences in the local food supply. For example, the use of various animal products such as fresh blood, lard, or manure, has been recommended strongly on repeated occasions for the past hundred years or more, with about as numerous reports of failure. In the present tests, each of these materials showed a definite ability to protect apple shoots, when compared with untreated

bark, or even when compared with a few of the other mixtures tested. But in comparison to the best mixtures, either blood, lard, or manure has so small an effect that it is negligible from the practical point of view. Yet it is easy to visualize field conditions where, in the presence of an abundance of acceptable wild food, the slight protection furnished by these materials might be sufficient to make the treated young trees undesirable enough to prevent the rabbits' feeding.

When selecting a material for field use, the most extreme conditions likely to be encountered must be considered. While a less effective repellent may "get by" for several years, it may fail when it is most needed. In the table listing the materials which have been tested, Group I contains only those showing an ability to protect under severe conditions. Certainly a number of other mixtures, included in Group II, may be practical for use under more favorable conditions.

As mentioned in a previous publication (2), limited tests of a few of the more effective repellents were made to determine their effect on growing young fruit trees. These repellents have been so annotated in the list of formulae. It should be distinctly understood that none of the rest of the formulae has been tested for safeness on living bark. Some of them are known to be dangerous to use on young fruit trees. Any trials of repellents untested against trees should be made with the greatest caution.

MIXTURES TESTED

In the following lists of mixtures tested, the figures following the ingredients show the proportional parts used by weight in mixing that formula.

GROUP I

The following mixtures are the best of those tested. Any further trials of the materials listed in this paper should probably come from this group, since these materials have not failed against cottontails except at the end of severe tests. Any repellent in this group is as good as a rosin 2, ethyl alcohol 1 mixture.

Rosin 3, ethyl alcohol 2. This concentration of the rosin-ethyl-alcohol repellent was used in all tests of effect upon trees. It showed no deleterious effect in any of the experiments carried out.

Rosin 5, linseed oil 1. This was one of Neilson's recommended formulae (reference 9) but tests on growing trees confirm the previous observations that damage will result from its use. There is no doubt that this is an

effective rabbit repellent, for in one test this material after 6 months' weathering on the trunks of small trees, was as effective as fresh treatments of certain other repellents included in Class I, showing a lasting quality unmatched by any of the other materials in this particular test.

Rosin 5, linseed oil 1, gasoline 3

Linseed oil 5, copper carbonate 4

Rabbit Repellent 96A (reference 4) (Pocatello Supply Depot, U. S. Fish and Wildlife Service, Pocatello, Idaho)

Venice Turpentine, normal consistency. (Magnus, Mabee and Reynard, Inc., New York, N. Y.)

Burt Gum, (National Adhesive Corporation, Chicago, Ill. Mikah Burt Gum No. 517). This product gave evidence of damage to young trees in several tests.

Tree Tanglefoot, normal consistency (The O. and W. Thum Company, Grand Rapids, Michigan)

Dow 3. A phenolic tar (Dow Chemical Company, Midland, Michigan No. 716-2-252)

Castle Chemical Rodent Repellent. (Castle Chemical Company, Castle Rock, Minnesota). This product was tested on growing trees and produced no damage according to the measurements used. Rubbing the tree bark with snow before applying the repellent was found not to decrease the effectiveness against rabbits.

GROUP II

The following are mixtures which must be rated as having moderate protective ability, as shown by the tests. This group contains mixtures which may have been moderately good in one test, and poor in another, or have shown a general moderate protective ability. In case of doubt as to whether a mixture should be put in this group, or in the group of the best mixtures, it was always placed in this group. The standard in this group is a rosin 1, ethyl alcohol 2 mixture.

Rosin 10, linseed oil 1, gasoline 20. This formula, with the proportion of gasoline varied down to equal parts of rosin and gasoline, was uniformly in this class. Gasoline was not so satisfactory as ethyl alcohol when used as a carrier for the rosin, owing to solubility difficulties.

Rosin 20, linseed oil 1, ethyl alcohol 12. This formula just fell within the present classification.

Rosin 1, ethyl alcohol 1. This formula must also be included in Class II, since it was not so effective as the rosin-ethyl-alcohol 2 to 1 formula which sets the standard for Class I.

Rezyl X-315 diluted with equal volume of ethylene dichloride. (American Cyanamid and Chemical Company, New York, N. Y.)

Rosin emulsion from Dr. E. J. Miller, Experiment Station Chemist, Michigan State College. This preparation is as effective as any rosin-alcohol mixture which deposits the same amount of rosin.

Asphalt emulsion 3, copper carbonate 2, water 4. (reference 4)

Dow 2, A phenolic tar (Dow Chemical Company, Midland, Michigan No. 716-2-251)

Dupont 1 N-794 A11, and Dupont 1 N-834 A4, rosin 1, ethyl alcohol 4, containing small percentages of tetramethylthiuram disulfide, and tetraethylthiuram disulfide, respectively. (E. I. Dupont de Nemours and Company, Wilmington, Delaware)

Carbosota "a highly refined creosote oil" (Barrett Company, New York, N. Y.)

Champion Graphite Axle Grease No. 7176 (Sears, Roebuck and Co.)

Tree Tanglefoot, diluted with ethyl alcohol, equal parts (The O. and W. Thum Company, Grand Rapids, Michigan)

The following formulae fall into Group II after weathering on trunks of small trees for the stated periods of time.

Rosin 5, linseed oil 1—weathered one year.

Rosin 3, ethyl alcohol 2—weathered six months

Castle Chemical Rodent Repellent—weathered six months

Burt Gum—weathered six months

GROUP III

The following are mixtures ranging from those of some protective ability, but of less than Group II, down to those of no value.

Rosin-ethyl-alcohol formulae in dilutions from rosin 1, ethyl alcohol 4, through rosin 1, ethyl alcohol 10 fall in this group. Their effectiveness varies in proportion to the amount of rosin deposited

Rosin-linseed oil formulae mixed in proportion from rosin 1, linseed oil 2 to rosin 1, linseed oil 10

Rosin-ethyl-alcohol formula with linseed oil. Dilutions of this formula ranging from rosin 5, linseed oil 1, ethyl alcohol 10, to rosin 5, linseed oil 1, ethyl alcohol 50 all fell within this class

Concentrated lime-sulfur solution, painted on, either one or two coats

Red clay (Ontonagon clay)

Red clay with hair plaster

Hair plaster alone

Dowax, a paraffin emulsion (Dow Chemical Company, Midland, Michigan)

Red clay and Dowax

Red clay, Dowax, and rockwool

Dowax and aluminum powder

Dowax 1, asbestos fibers, either 1 part or 6 parts

Dowax and hair plaster

Dowax, hair plaster and cement

California Tree White, normal consistency and mixed extra thick

California Tree White, normal consistency, with the following materials added:

- Glue
- Copperas
- Gypsum
- Copperas and glue

Spray glue

Spray glue and copperas

Spray glue and lamp black

Venice Turpentine 1, ethyl alcohol 8. (Magnus, Maybee and Reynard, Inc., New York)

Burt Gum 1, gasoline 8. (National Adhesives Corp., Chicago)

Tannic acid solution

Asphalt emulsion. Hunts Acme Grafting Compound for Orchardists (M. H. Hunt and Son, Lansing, Michigan, now M. J. Beck Company, Lansing, Michigan).

Asphalt emulsion and tannic acid

Asphalt emulsion, tannic acid, and copperas

Asphalt emulsion and copperas

Asphalt emulsion and sulfur

Asphalt emulsion 3, flaked mica 1

Asphalt emulsion and pyrethrum

Asphalt emulsion and cement

Asphalt emulsion and sand

Asphalt emulsion, sand, and cement

Asphalt emulsion, sand, cement, and tannic acid

Stanolind cut back asphalt, cold mix (Standard Oil Co. of Indiana)

Stanolind diluted with gasoline

Gypsum in water

Sava-Tree Pruning Paint (Southern Cotton Oil Co., Savannah, Georgia)

Sava-Tree diluted with gasoline

Lamp black

Spray glue and lamp black

Ordinary carpenter's glue in water

Whitewash

Whitewash with glue and copperas

Whitewash and tannic acid

Whitewash, tannic acid and glue

Whitewash, glue, copperas, and lamp black

Dried milk

Dried milk and lamp black in water

Glue, hair plaster and sulfur

Hair plaster and tannic acid

Soap, cement, rockwool, and plaster

Soap, glue, and copperas

Soap solution

Glue and hair plaster

Plaster and hellebore

Oil of citronella

Oil of citronella in Dowax

Oil of citronella in asphalt emulsion

Copperas

Wax 211 (National Wax Company, Chicago)

Dow 1, a phenolic tar (Dow Chemical Co., Midland, Michigan No. 716-2-251 acetone solvent)

Bordeaux mixture (2-4-100)

Casco Glue grade A, 1 part, water 1 part. (Casein Co. of America, New York)

Casco Glue grade A, 1 part, water 4 parts, a thin solution of the previous mixture

Casco Cascamite (Casein Co. of America, New York)

Sherwin-Williams Rodent Repellent—sulphurized linseed oil. (The Sherwin-Williams Co., Cleveland, Ohio)

Sulfurized oil, from Prof. J. A. McClintock of Purdue University

Black gloss enamel 4-hour drying, pigment 3%, vehicle 97% (S. S. Kresge and Company)

Lusterex Enamel, Chinese Red, tung oil and bakelite, Pigment 7% (Con-Ferro Paint and Varnish Company, St. Louis, Missouri)

Endurance Paint prepared—723 dark green—pigment 44.5%, liquid 55.5% (Glidden Company, Cleveland)

Niergarths Floor Seal (Niergarths, Inc., Lansing, Mich.)

Barber Genasco Asphalt Roof Coating (Barrett Co., New York)

Trinadad asphalt, melted and applied hot

Spread-ol, a fish oil product. "A sticker and spreader for fruit and vegetable insecticide spray" Silmo Chemical Company, Vineland, New Jersey)

Whale oil

Elgetol (Standard Agricultural Chemicals, Inc., Hoboken, New Jersey)

Tinstick paste (National Adhesives, Chicago)

Dupont Fermate 1, water 7. (E. I. Dupont de Nemours and Co., Wilmington, Delaware)

Dupont Fermate 1, asphalt emulsion 5 and water 3

Valvoline universal-joint grease. (Valvoline Oil Company, Cincinnati, Ohio)

Valvoline water-pump grease, waterproof

Valvoline transmission grease X-18

Valvoline chassis grease GL-1

Paradichlorobenzene 2, miscible oil 1

A "bodied" linseed oil

Cow manure

Cow manure 5, lamp black 3, sulfur 1

Cow manure 1, sulfur 1

Fresh beef blood

Beef blood 10, asphalt emulsion 9

Dried blood meal 1, asphalt emulsion 1

Lime 30, sulfur 2, hellebore 2, whale oil 7, lamp black 1, mixed with water to the consistency of a thick paint

Rosin emulsion from Dr. E. J. Miller, Experiment Station Chemist, a thinner mixture than the rosin emulsion listed in Group II and like it, closely comparable in effectiveness with rosin-ethyl-alcohol mixtures depositing the same amount of rosin.

Nicotine sulfate 1, asphalt emulsion 15

Asphalt emulsion—dry lime-sulfur preparation (reference 4) Wyodak Spreader Clay 1 (Wyodak Chemical Company, Cleveland, Ohio), Orchard Brand dry lime-sulfur (General Chemical Company, New York) 6, asphalt emulsion 8 and water 20

The following substances when applied alone fall within this classification.

Ethyl alcohol, linseed oil, both raw and boiled, gasoline, water glass (sodium silicate)

The following materials fall within this classification after weathering for the stated period of time.

Rosin 3, ethyl alcohol 2, weathered one year

Castle Chemical Rodent Repellent, weathered one year

Burt Gum, weathered one year

Rosin, ethyl alcohol, and linseed oil, weathered six months or one year

Dow 3, weathered six months or one year

SUMMARY

A number of materials were tested as repellents against the cottontail rabbit, *Sylvilagus floridanus mearnsii* (Allen), and the results are listed.

It is suggested that disagreement among field reports of effectiveness of repellent mixtures may be due partly to local differences in rabbits' food preferences, and to differences in the severity of test conditions.

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AN IMPROVED GREENHOUSE BENCH

By C. E. SHERWOOD
SECTION OF HORTICULTURE

BECAUSE of the diversity of uses, no perfect greenhouse bench exists. However, the following bench meets the common demands of low cost, long-lasting, durability, simplicity, quickness to install, and portability.

Metal benches and monolithic type concrete benches are proving very serviceable. However, there is no exact proof of the long-time ability of the one to stand corrosion of greenhouse conditions or the other to withstand frequent steam sterilization. Both are more costly than desirable, even when figuring the yearly per square feet cost on a 20-year life basis.

Sectional concrete benches have been tried for several decades (5). As a rule they have been more satisfactory than solid concrete benches (one-piece concrete benches). This is probably the result of greater stresses and expansion differences occurring more often in the larger units.

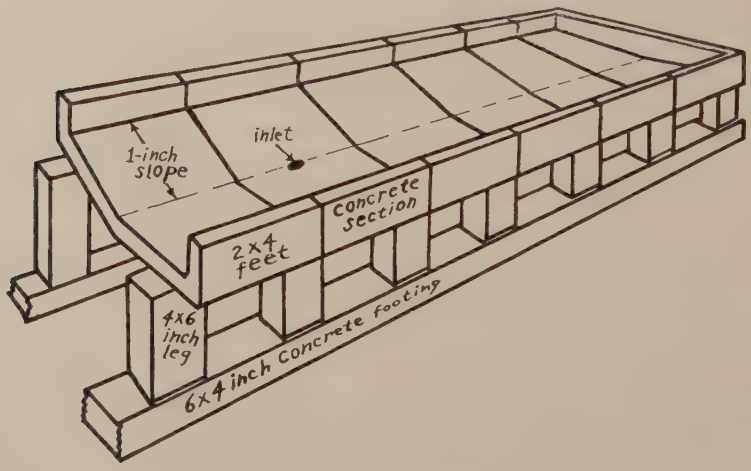

Fig. 1. Concrete greenhouse bench.

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A bench of the sectional concrete type (Fig. 1) has been well received in Iowa. Mr. Art Smith of the Kemble-Smith Floral Co. of Boone, Iowa, has been making this bench for 30 years, and he likes it better than the one-piece concrete benches. Since he stopped using reinforcement, about 15 years ago, the cracking and breaking have been negligible. This bench has proven very satisfactory for general cultural practices, including steam sterilization. It is cast in 2-foot lengths of bench with the 6-inch side walls and bottoms complete in each section. The sections are all alike, except for the end sections which have the end as well as the sides in the 2-foot section. A marked improvement is the use of continuous concrete footings or sills to support the bench. These footings can be poured along existing benches, making possible bench replacement only a matter of a few hours. Raised benches are supported by 4- by 6-inch or 6- by 6-inch concrete legs set on this footing. Concrete blocks may be used as legs.

Mr. Smith had a dealer make these sections for $1.50 each. At the present time it is estimated that similar sections would cost about $2.50 in Michigan.

The following bench is a Michigan modification of the Smith bench, embodying the desirable characteristics of the V-bottom watertight benches popularized by Ohio (2) and Cornell (3). It is a satisfactory type for constant water level growing or soilless culture. The characteristics are similar to the Missouri bench (4), and older sectional concrete benches, but differ in construction and reinforcement.

The Michigan State bench is cast in complete 2-foot sections with attached sides, as is the Iowa Smith bench. The bottom slopes from 6 inches deep at the sides to 7 inches deep at the center. When erected, the sections are leveled so that the V-trough slopes to the nearest outlet, which is cast in every fifth section and cemented together. After a coat of asphalt emulsion, the bench appears similar to the one-piece V-bottom bench.

The forms can best be made to enable one to pour the sections upside down. The inside of the forms may be built of 1-inch lumber; the sides and ends of 2- by 10-inch lumber. The center form should taper so the concrete section can be easily removed. The outer boards are held in place by pins or cross ties, making them removable.

A concrete mixture of 1 part cement, 2½ parts pea gravel, and 2¼ parts sand is satisfactory. No reinforcement should be used. Galvanized reinforcing will probably but postpone reinforcement troubles. Inlets or drainage in some sections may be made by nailing a large

cork on the V of the center form and fitting a split or bolt union half with a 6-inch nipple on the cork so the union is cast in the center of the concrete section bottom.

Oil the form with old crankcase oil, pour the concrete and thoroughly agitate and settle it. After tamping, remove concrete in excess of 2-inch thickness by drawing an inverted V over the form and resting on and between the side boards.

Legs 4 by 6 inches, about 16 inches long, should be poured in the same matter. The footing should be poured in place and only slightly above ground level. The footing trench should be dug carefully so the bottom of the 4- by 6-inch footing will rest on undisturbed ground. Pouring the footing inside or outside the old bench legs will permit faster change of benches.

Wooden forms may be filled every 24 hours, but they result in less uniform sections than would be possible with metal forms. After the sections have been removed, they should be kept damp at least a week for curing. The concrete joints should also be kept damp by syringing them occasionally for at least 3 days after erecting the bench unless damp soil is placed over them.

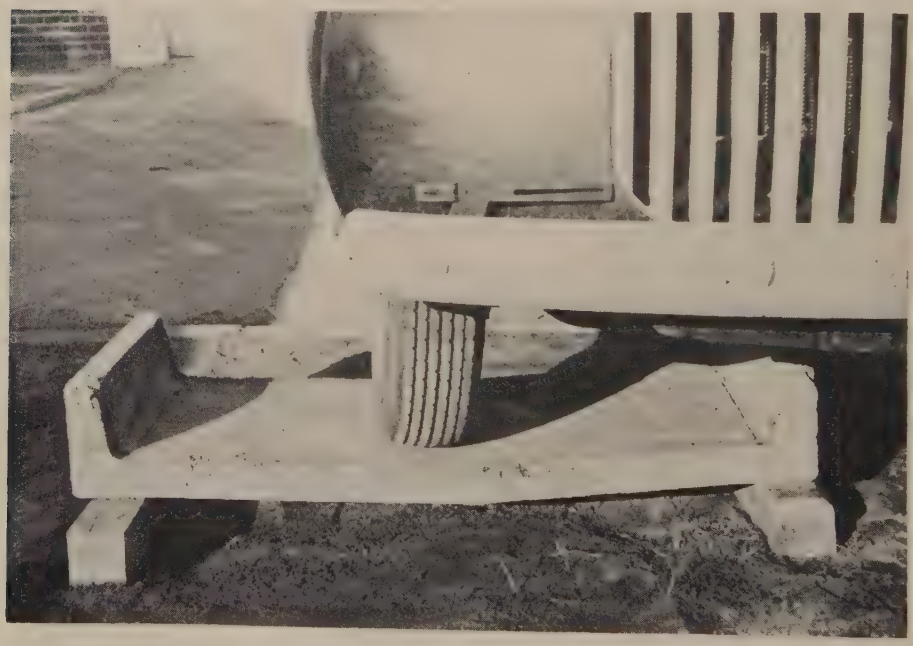

Fig. 2. Concrete bench section showing load resistance.

The author and his associates have found this bench resistant to breaking under pressure, or cracking with steam sterilization. A section supported at each end with 4 by 4's supported a truck wheel bearing about 1,500 pounds. Temperature trials to 180° F. caused no sign of injury.

Like the regular V-bottom bench, this bench is suitable as a watertight bench and for ordinary plant culture. Other advantages are its durability, economy of construction, and suitability for movement or replacement of damaged parts, if any occasion should occur.

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THE WHY AND HOW IN CULTIVATING CORN

By A. G. WEIDEMANN
SECTION OF SOIL SCIENCE

THE QUESTION of why we cultivate corn is ever with us. Considerable progress has been made in methods of corn cultivation since the days of the two-shovel cultivator, but there still seems to be opportunity for improvement.

If one were to canvass farmers as to their reasons for cultivation, no doubt, the two most common answers would be to conserve moisture and to kill weeds. There would probably be other reasons given, some of which might be valid from the viewpoint of experimental evidence while others may not be supported by research results. The way a farmer cultivates is likely to be influenced by his reasons for cultivating. Knowing why one cultivates and what the effects of cultivation are should modify his method of procedure.

Frequently the writer has heard farmers comment on how necessary they found it to keep the cultivator running during dry periods to conserve moisture and keep the corn growing. There has been a considerable amount of investigational work done along that line in various parts of the country, and the evidence does not seem to support that assumption.

REVIEW OF LITERATURE

In experiments conducted at the Ohio (4) Experiment Station from 1883 to 1887 little was gained in yield by excessive cultivation although the yield was reduced about 75 percent by not cultivating at all and allowing the weeds to grow. At the same station (5) in 1890 corn cultivated 4 inches deep yielded 45.5 bushels per acre while that cultivated very shallow yielded 47.1 bushels. Waters (7), working at the Missouri Station, reported an average yield, for 1889 and 1890, of 53.5 bushels of corn from deep cultivation, 66.9 bushels from shallow cultivation, and 63.8 bushels from shaving the weeds off at the soil surface with a sharp hoe without forming a mulch. Sturtevant (6),

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Director of the New York Station, in 1886, made the following statement: "Cultivation is not beneficial to the corn plant except so far as removing the weeds is concerned." He reported, for 1886 yields, 18.1 bushels of corn per acre where weeds were allowed to grow, 70.5 bushels where they were hand-pulled, and 56.8 bushels where the plots were cultivated and hoed.

Some cultural work with corn started in 1888 by Morrow at Urbana, Illinois, reported by Mosier and Gustafson (3), later reviewed by Wimer and Harland (8), and still later reviewed by Wimer (9) showed little advantage of shallow cultivation over shaving off weeds with a sharp hoe, but considerably more advantage of shallow cultivation over deep cultivation. They also reported a reduction of about 16 percent in yield from pruning corn roots to a depth of 4 inches with a knife in addition to shaving the weeds off with a sharp hoe. This might be comparable to pruning the roots by cultivating too deep. As a 5-year average, using yields from a plot that was plowed, fitted and the corn cultivated shallow three times as 100 percent, Wimer and Harland (8) reported comparative percentage yields from a number of different treatments as follows:

Plowed, fitted and the corn cultivated shallow three times	100.0 percent
Not plowed nor cultivated, weeds removed by shaving with a sharp hoe	80.5 percent
Plowed and fitted, not cultivated, but weeds shaved off	114.3 percent
Plowed and fitted, weeds allowed to grow	16.6 percent
Plowed and fitted, weeds allowed to grow, irrigated	21.8 percent
Plowed and fitted, cultivated shallow, irrigated	119.3 percent
Plowed, fitted, cultivated shallow, irrigated and fertilized	146.6 percent

It can be gleaned from these figures that irrigation did not help much where weeds were allowed to grow and no fertilizer was applied. This indicates that the use of fertility by weeds, as well as the using up of soil moisture, is an important factor in reducing corn yields. As a 4-year average of corn yields on a sandy soil, Grantham and Millar (2) reported 37.9 bushels where soil was cultivated 3 inches deep and 41.8 bushels, or an increase of 3.9 bushels, where soil was not cultivated but weeds removed. Cates and Cox (1), investigating

the weed factor in the cultivation of corn, conducted 125 experiments in 28 states on the subject. The average results of all their experiments showed that the yield from plots that were not cultivated, but the weeds kept down by shaving, was 99.1 percent as great as from plots that were cultivated in the usual way. Their results also showed that cultivation is somewhat more beneficial to corn grown on heavy soils than to that grown on the lighter types.

EXPERIMENTAL

In 1933 an experiment was started on Hillsdale sandy loam on the Michigan State College Farm to test and demonstrate the effect of cultivation on corn yields on that type of soil as compared with shaving the weeds off at the soil surface with a sharp hoe. Corn followed clover in a rotation of corn, barley and clover, and the experiment included both fall and spring plowing for corn as well as the other cultural practices. Alfalfa was harvested the first year in place of clover as the field was growing alfalfa when the experiment was started. Corn, which was drilled in rows rather than check-rowed, was fertilized with 200 pounds per acre of 2-12-6 applied in the row. Corn stubble was disked for barley, which was also fertilized with 200 pounds per acre of 2-12-6 drilled with the seed and seeded to clover. Barley and clover yields are given in Table 1 along with the corn yields, as a measure of the productivity of the soil on which the corn was grown. After the corn was drilled, the areas to be shaved were raked smooth with a leaf rake, without disturbing the seed or fertilizer, to facilitate shaving off the weeds later. Weeds were shaved off three or four times during the summer as required, never allowing them to get much more than an inch high. The cultivated plots were cultivated fairly shallow three times during the summer and the weeds in the rows and those appearing after cultivation was discontinued were removed with a hoe. Corn was planted thick enough to provide a full stand and after the plants came up they were thinned to an average of 15.6 inches apart in the row.

DISCUSSION

No striking differences could be observed during the growing season between the corn on the cultivated soil and that on the shaved soil. Figures 1 and 2 show conditions which are typical of corn grown in this experiment. The different shades of color exhibited are due

TABLE 1—*Effect of cultivating vs. shaving off weeds on corn yields on both spring- and fall-plowed soil. (Bushels of grain and pounds of stover, straw and hay).*

Treatments		Product	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	Average
Corn yields																	
Spring-plowed	Shaved	Grain	37 5	16 9	59 1	25 9	65 4	58 5	**	35 0	27 8	78 8	49 3	21 8	60 3	21 6	42 9
		Stover	3,790	4,353	3,535	3,286	4,002	4,195	———	3,330	2,819	4,767	4,101	2,409	5,352	1,923	3,682
	Cultivated	Grain	39 8	23 1	60 7	27 4	65 6	60 0	———	39 5	31 4	77 2	54 1	15 6	64 1	22 9	44 7
		Stover	4,356	4,366	3,656	3,691	3,849	4,188	———	3,840	2,963	4,288	4,101	2,801	6,715	2,209	3,925
Fall-plowed	Shaved	Grain	35 7	14 2	59 1	24 0	62 7	56 8	———	28 4	30 2	84 1	55 1	17 1	56 6	17 8	41 7
		Stover	3,554	3,690	3,609	2,539	3,949	3,998	———	3,547	3,224	5,302	4,325	2,334	5,284	2,010	3,643
	Cultivated	Grain	43 0	8 2	66 1	28 7	63 5	58 6	———	29 2	27 4	84 2	58 1	18 9	53 7	19 9	43 0
		Stover	3,401	4,350	3,949	3,491	4,008	4,020	———	4,114	3,217	5,060	4,580	2,632	5,146	2,073	3,849
Barley yields																	
Spring-plowed*	Shaved*	Grain	———	15.6	51 3	28 6	26 4	39 1	24 7	44 3	27 9	28 3	13 9	20 6	31 1	34 8	29 7
		Straw	———	1,094	2,155	1,097	1,162	1,727	1,431	1,867	1,359	1,416	1,377	1,208	1,307	1,649	1,450
	Cultivated	Grain	———	15 7	51 3	28 4	31 4	36 7	24 1	43 7	27 0	26 6	12.3	19 7	33 4	32 3	29 4
		Straw	———	1,226	2,155	1,123	1,392	1,608	1,436	1,867	1,348	1,343	1,369	1,167	1,302	1,561	1,454
Fall-plowed	Shaved	Grain	———	13 9	50 8	29 2	27 9	35 9	31 8	44 5	29 2	32 5	16.4	21 6	39 9	35 0	31 4
		Straw	———	1,133	2,020	1,156	1,232	1,882	1,534	1,856	1,426	1,213	1,478	1,265	1,587	1,561	1,488
	Cultivated	Grain	———	15.1	53.5	30.1	31.9	39.0	28 4	40.4	30.9	27.1	13.5	21.0	37.3	28.4	30.5
		Straw	———	1,177	2,256	1,211	1,423	1,706	1,384	1,691	1,551	1,317	1,299	1,203	1,504	1,333	1,466
Clover yields* **																	
Spring-plowed	Shaved	Hay	4,366	56	———	4,098	———	3,451	874	———	3,508	2,351	2,483	1,769	2,523	2,905	2,027
	Cultivated	Hay	4,556	84	———	4,248	———	3,628	758	———	3,446	2,361	2,944	1,491	1,864	2,927	2,022
Fall-plowed	Shaved	Hay	4,642	348	———	3,088	———	3,613	925	———	3,615	2,266	2,507	2,273	1,413	2,931	1,973
	Cultivated	Hay	3,982	318	———	3,148	———	3,539	1,261	———	3,828	2,759	3,039	2,417	1,643	3,112	2,075

*Dates of plowing and other cultural practices pertain only to the corn crop. These designations in connection with barley and clover yields indicate that those yields were obtained from plots so treated for corn.

**The 1939 corn yields are omitted because the corn planter failed to distribute fertilizer properly on these plots in 1939.

***The 1933 crop was alfalfa because the field was growing alfalfa when the experiment was started. There were three clover failures and some near failures owing to drought. The average yields are the total yields for eleven harvests divided by 14 because if near-failures are included in the averages total failures should be included also. When clover failed it was re-seeded the following spring to provide a sod to be plowed down but there was no hay to harvest.

Fig. 1.

Fig. 2.

Figs. 1 and 2 show similarity between shaved and cultivated corn at different stages of growth. Left of tall stake: Weeds shaved off at surface of soil with a sharp hoe. Right: Soil cultivated three times. Fig. 1. Taken July 13, 1946. Fig. 2. Taken August 20, 1946.

to the direction in which the sun's rays are reflected. Sometimes it appeared that the brace roots came out higher on the stalks on the shaved soil than on the cultivated soil, and when open-pollinated corn was grown it tended to fall down a little easier on the shaved soil. This could easily be true, since in cultivating soil is usually piled up to some extent along the rows.

The data in Table 1 give the annual yields of all crops grown on the various plots in the rotation as well as the average yields for the period. While there are some variations in the annual yields of clover and barley from the differently treated plots the average yields are surprisingly close, indicating that the natural productivity of the different plots is very similar, and variations in corn yields from the differently treated plots should be due to treatments and not to differences in the natural productivity of the soil. A glance at the corn data also shows some variations in the annual yields from differently treated plots. The differences in yields between years are largely due to weather conditions, but the differences among different plots within a given year are probably just chance variations since the averages for both grain and stover for the whole period from different plots are surprisingly similar and only slightly in favor of cultivating. Although the data presented here do not show the effect of allowing weeds to grow as compared with cultivating or shaving them off with a sharp hoe, they do show that there is very little advantage in cultivating if the weeds can be removed some other way. Incidentally, there is nothing in the results in favor of either fall or spring plowing.

CONCLUSIONS

The question is often asked as to how to get rid of weeds without cultivating. At present there seems to be no other practical way. Until some selective spray material, or some other selective device, is developed that will kill all weeds without injuring the corn we shall probably continue to cultivate, but there seems to be no particular advantage in cultivating any deeper or any oftener than is necessary to kill weeds. Deep cultivating prunes the roots and may seriously reduce the yield. Before the corn plant is very large its root system so completely fills the feeding area of the soil that there is very little chance for water moving up from below to reach the surface of the soil where it can be lost. The plowed soil is more valuable as a feeding area than it is as a mulch to prevent evaporation of water. Also,

when a soil gets dry enough it will normally form a protective layer at the surface which will serve the same purpose in preventing evaporation as a mulch made with a cultivator.

Under certain conditions, there may be some advantages in cultivating besides killing weeds. A loose, rough surface will sometimes assist rain water in entering the soil. Also when soils of the heavier types get dry on the surface they tend to crack. The cracking not only tends to permit water to evaporate from below but also, if severe enough, it will sever plant roots and produce the same effect as root pruning. This situation can be remedied to some extent by shallow cultivation.

It seems advisable, according to these results and the results of similar experiments conducted on other types of soil, to cultivate only often enough and deep enough to control weeds, always being careful not to cultivate deep enough to seriously prune the roots.

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POWDER-POST BEETLES: THEIR CONTROL IN WOOD AND STRUCTURAL TIMBERS

By E. I. McDANIEL
SECTION OF ENTOMOLOGY

POWDER-POST BEETLES attack seasoned dry hardwoods. Under natural conditions they are scavengers breeding in hard wood slash which accumulates around lumbering operations or in dead trees, but they become an economic factor when they attack structural timbers, finishing lumber, or furniture.

The typical powder-post beetles belong to the genus, *Lycus*. Their destruction is limited to the sapwood of hard woods such as ash, hickory, maple, and oak. They winter as larvae, pupating in the spring, and the adults emerge in summer. They may be active for from 4 to 6 weeks, each female placing a hundred or more eggs. After hatching, the young grubs tunnel back into the sapwood filling their burrows with fine flour-like powder. Where a number of beetles work in close proximity the sapwood may be reduced to dust. The exterior remains normal except for occasional exit openings. It is this fine flour-like powder crowded through these openings which is indicative of powder-post beetle infestation.

Anobids, another group of powder-post beetles tunnel through the sapwood into the hard wood. Their tunnels are larger and more distinct than those of the typical powder-post beetle, and in place of

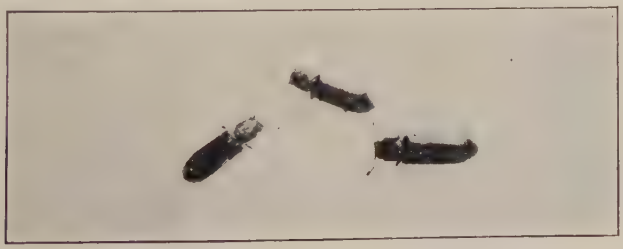

Fig. 1. Powder-post beetle, Lyctus planicollis, enlarged 3 x.

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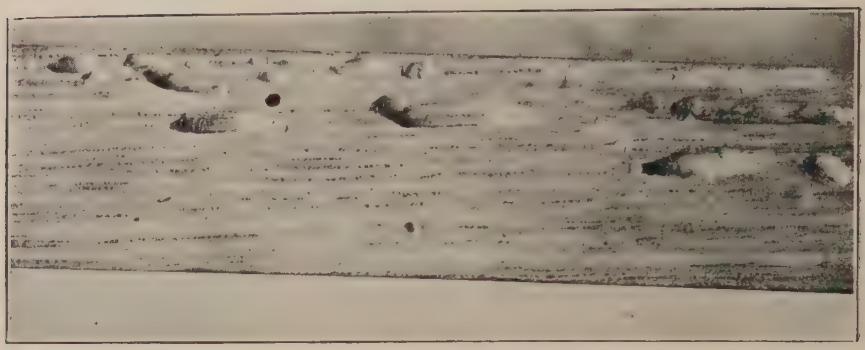

Fig. 2. Work of powder-post beetles in flooring cut to show tunnels, enlarged about 2 x.

the fine flour-like powder their tunnels are filled with an accumulation of coarse waste and definite pellets.

Powder-post beetles lay their eggs in cells or pores in wood and where these pores are filled with wax, varnish, or paint, the beetles find fewer places to deposit their eggs. Beetles will complete their development in wood infested before it is finished, and adults will emerge through exit holes to the surface. Paint, especially penetrating paint applied for the purpose of filling these pores, is an effective control under average conditions.

Various materials, properly applied, will kill a large proportion of powder-post beetles in structural timbers, but no material can be depended upon for 100-percent control because of the improbability

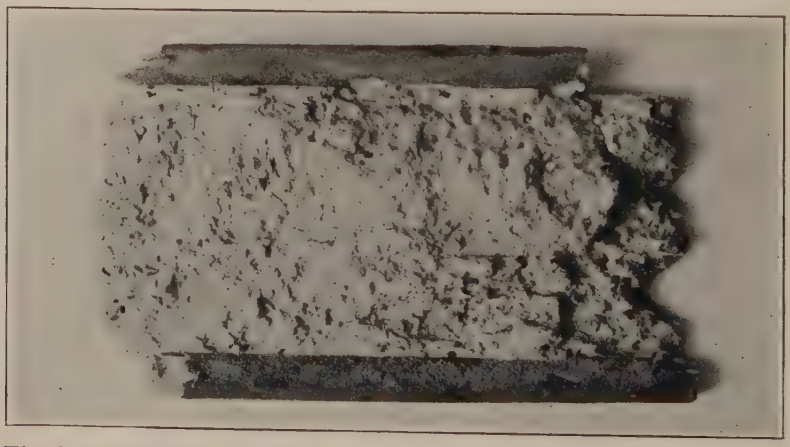

Fig. 3. Piece of wood split open to show inner part reduced to powder.

Fig. 4. Surface of piece of wood showing exit holes of powder-post beetles.

of securing thorough penetration; therefore, most applications should be followed for several successive years.

The following materials are suggested:

Lime-sulfur, 2 to 3 gallons in 100 gallons of water, applied to infested timbers with a power sprayer during the summer, will materially reduce the powder-post beetle population. The odor is objectionable and the application messy. Under some conditions this is a very satisfactory spray to use in barns, sheds, and other out-buildings.

Powdered borax, 10 pounds in 100 gallons of water plus 4 ounces of sodium lauryl sulfate or similar spreader, applied as suggested for lime-sulfur, will kill powder-post beetles. It can be applied to beams in basements, barns, and out-buildings, but it is not suitable on finished surfaces because of the excessive amount of water. (Take precautions not to drench hay or feed with borax.)

Pentachlorophenol, 5 percent in a petroleum solvent, has excellent penetrating qualities. Lumber treated with it takes a normal finish. It can be applied either as a spray or with a brush. It has residual qualities and the necessity of making additional applications is usually unnecessary if the original application has been thorough.

Dichloro diphenyl trichloroethane (DDT), 5 percent in a petroleum solvent, in an emulsifiable oil or as a wettable powder, applied

at concentrations suggested for residual sprays for fly control, will kill powder-post beetles. The early applications will be the most effective. The following concentrations are suggested: Wettable DDT (50 percent), 16 pounds in 100 gallons of water (6 ounces to 1 gallon), or the 25 percent emulsifiable oil, 1 part to 5 parts water.

Certain precautions must be observed in applying DDT. Avoid getting it on food or utensils used in the preparation of food. Where oil solutions or oil emulsions containing DDT are used, take precautions against inhaling the mist or permitting it to remain on the skin.

THE VACUUM HARVESTER FOR CLOVER SEED

By S. T. DEXTER and W. H. SHELDON
SECTIONS OF FARM CROPS AND AGRICULTURAL ENGINEERING

THE VACUUM HARVESTER for white clover seed, reported by Dexter and McKibbin,[1] was rebuilt in 1945 and 1946 to incorporate recommendations made after the first year of operation. The machine was enlarged to take a 6-foot swath and the fan speed increased to 2,600 R.P.M. by using the oversize tractor pulley furnished by the manufacturers of the tractor. At this increased speed, the fan consumed approximately 15 H.P. and moved about 5,000 cubic feet of air per minute. The fan housing was rotated 90 to discharge vertically, and a swivel elbow was used between the fan and the discharge pipe. This facilitated turning corners with the harvester and the 4-wheel trailer that was used for carrying the harvested material. The trailing wagon, 7 x 13 feet, has tight sidewalls 6 feet high, with a door 4 feet high in the rear. The top is of ¼-inch hardware cloth, covered

Fig. 1. A general view of the vacuum harvester and trailer.

[1]Mich. Agr. Exp. Sta. Quart. Bul., Vol. 27, No. 3, Feb. 1945.

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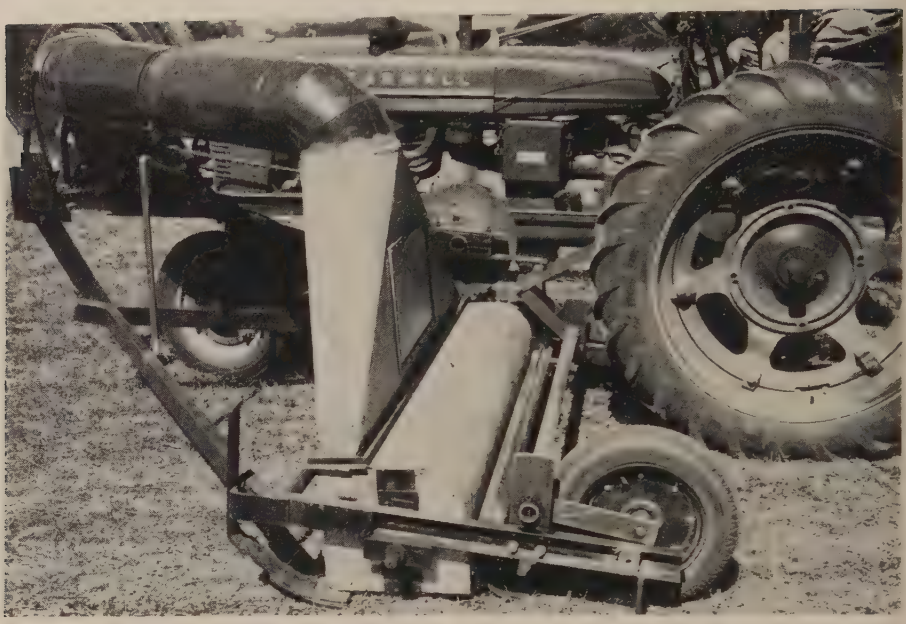

Fig. 2. Detail of construction of wheels and torsion arms.

with burlap to prevent seed from blowing out. Spring teeth, from the Case combine pickup attachment, were used on the rotating beater, which is now driven from the tractor rather than from the ground. These teeth were mounted on six pipes, parallel to the main rotor shaft. The rotor was made adjustable with respect to its housing. Either end of the rotating beater and its housing can be raised or lowered by the tractor operator by means of levers attached to the harvester wheels with pull rods and torsion arms. In the 1945 trials, without these necessary adjustments, considerable difficulty was encountered.

1945 TRIALS

In 1945 the machine was used on experimental plots and on an 18-acre field of ladino clover. The entire field of 18 acres was harvested, the machine picking up the dried forage directly from the swath. Owing to a rainy summer, the growth was rather large when the ladino clover was cut and, with rainy weather during harvest, new growth came up through the swaths. The field was rather weedy, with wild carrot and thistles as much as 3 feet tall. These tall weeds with their very stiff, woody stems, gave trouble, since they could not

get through the throat of the vacuum head. Finally most of them had to be picked up by hand and removed from the field. It was evident that a clean-out panel should be provided. During the 1945 season, experiments were run to see how rapidly the rotating beater should run, but at speeds from two to five times ground speed of the tractor, there was no apparent difference. The height of the machine from the ground is critical. The teeth of the beater must disturb, or throw into the air-stream as large a proportion of the heads as possible, and the machine must therefore be set low. On several acres, where the growth had been small, the machine was operated with the tractor in third gear, while on several acres the growth was so abundant that it was necessary to run in low gear, taking only part of a swath. On most of the area, the machine was operated in second gear, taking a full swath.

1946 TRIALS

The machine was again used on the 18-acre field and on an additional 32 acres (two fields) on the same farm. Owing to a dry season and the previous year's clipping, large weeds were not a problem. The machine was being used elsewhere when the farmer wished to start harvest. He, therefore, cut, raked into windrows, and loaded with a hay loader all that he could get before the machine was brought to his farm. The clover on the various fields varied considerably in height at the time it was cut, but none was larger than in 1945. The clover was cut with a 7-foot mower, and was raked three swaths to the windrow. On part of the area a three-bar rake was used and on part, a four-bar rake. A steel-bottom push-bar-type loader in excellent condition was used for loading.

The vacuum harvester was used only to salvage material that the farmer had missed. First, the vacuum harvester was run over the areas where the windrows had been, to salvage clover missed by the loader. Then two swaths with the harvester were taken on the strip between two windrows, to salvage clover missed by the side-delivery rake. These three swaths with the harvester covered perhaps 80 to 90 percent of the area raked into each windrow. All lots were separately stacked and subsequently run through a clover seed huller. The seed from each lot was cleaned, separately. Table 1 describes the fields and gives the yields and methods of harvest.

TABLE 1—*Amounts of seed salvaged under different conditions by the vacuum harvester.*

Acres	Field	Condition of field	Rake used	Where obtained	Seed, lb.	Seed, lb. per acre
20	I	Very tall, 12", when cut.....	3-bar	Windrows area.....	217	10.9
17	I	Very tall, 12", when cut.....	3-bar	Between windrows.....	60	3.4
12	II	Medium tall, field rough.....	3-bar	Windrows area.....	146	12.2
12	II	Medium tall, field rough.....	3-bar	Between windrows.....	170	14.2
6	III	Short, 4–5", old field.....	3-bar	Windrows area.....	112	18.7
6	III	Short, 4–5", old field.....	3-bar	Between windrows.....	101	16.8
7	III	Short, 4–5", old field.....	4-bar	Windrows area.....	115	16.4
7	III	Short, 4–5", old field.....	4-bar	Between windrows.....	83	11.9

From the data in Table 1, it can be seen that on the field where the clover was long, the rake did a good job. Even so, well over 10 pounds of seed per acre was recovered from the windrows and the swath. On the 13-acre field that was rather rough, and with medium growth, a great deal more seed was missed by the rake, and somewhat more by the loader, amounting in all to about 25 pounds of seed per acre. On the field where the clover was still shorter, more seed was missed by the rake and by the loader, with a total of over 35 pounds per acre. On this area, the four-bar rake seems to have done a somewhat better job than the three-bar rake, although still missing a lot of seed-heads. Final figures indicate that the total amount of seed salvaged was about one-half as much as the farmer obtained in his harvest operations with rake and loader.

While the machine was being used on these areas, the pull rods on the new levers were insufficiently long to permit the machine to be lowered to the best working position. As previously mentioned, part of the area of the field was untouched by the machine because of the wide mower used. To determine how much more seed could be picked up if the field were gone over a third time, four quarter-acre areas were harvested, running the harvester at right angles to the original

TABLE 2—*Weights of total material, of soil and of cleaned seed obtained.*

Field	Teeth position	Total material		Dust and sand		Cleaned seed	
		Lb.	Lb. per acre	Lb.	Lb. per acre	Lb.	Lb. per acre
I.....	High.....	128	152	18	72	2.85	
II.....	High.....	80	320	13	52	1.93	9.35
III.....	High.....	90	360	15	60	2.23	
III.....	Low.....	141	564	27	108	4.05	16.20

direction. On one trial, part of the air was let out of the tires in order to get the rotor teeth closer to the ground. Table 2 shows the results of these trials.

The figures in Table 2 reveal that an average of about 9 additional pounds of seed per acre was picked up when the teeth were somewhat too high, and about 16 additional pounds when they were lowered. When the teeth were lowered, proportionally more soil was picked up as well as more vegetable material, including a certain amount of green stolons. Even with the teeth "high," their tips would hit the floor when the machine was set up on a smooth platform. In practice, therefore, the teeth must drag somewhat to allow for irregularities in the field.

The machine, with lengthened pull rods, was taken onto the experimental plots. These were growing a ladino clover and brome grass mixture, containing about 60 percent brome grass by weight. The machine was run with the tractor at full throttle in low, second and third gears. Head counts were made behind the machine on measured areas, selected at random. The counts varied widely, depending upon the roughness of the land. As a check, one-one hundredth acre plots were similarly harvested, and the seed recovered on a clipper mill, without further threshing. Previous experiments had shown 80-100 percent threshing by the harvester itself. Table 3 shows the results of these harvesting methods.

From this table, it would appear that it made very little difference in which gear the tractor was run, on material that was not too heavy. On heavy growth in the same field, running the machine in low gave satisfactory performance, while the work was done very poorly in third. By ordinary observation, the operator can tell whether the machine is working properly, or if it is being overcrowded. On most

TABLE 3—*The effect of tractor speed on the efficiency of operation of the vacuum harvester.*

Gear	Trial No.	Times over	Total material	Seed per acre	
			Lb. per acre	Lb. obtained	Lb. unrecovered
Low	3	1	1,440	66	
Low	7	1			8
Second	2	1	1,470	67	
Second	7	1			7
Third	3	1	1,450	65	
Third	5	1			12

fields, operation in third gear, full throttle, is too fast for the comfort of the driver, the good of the machine, or the efficiency of harvest. At full throttle in low, the machine will harvest about 2 acres an hour (of working time). Usually the tractor is operated in second gear, where the machine makes about a full load on level land. Approximately a gallon of gasoline was used an acre.

On another farm, a field of about 7 acres was cut for seed following several showers, and immediately before a heavy downpour of rain. The short clippings were driven into the stubble, and by the time they were reasonably dry, a new growth of 3 or 4 inches had been made. On part of the field, harvest with a combine was attempted, but the yield of seed was so low that the attempt to harvest was abandoned. The vacuum harvester was put into this field. To do a satisfactory job it was necessary to run the tractor in low, with the beater set very low. Considerable green material was picked up, so that the clover was run through a huller at once to get the seed before it heated. Approximately 700 pounds of seed was obtained. Gleanings by hand from measured areas indicated that about 16 pounds of seed per acre was left after one time over the field. The field was again covered with the machine, at right angles to the original harvest, after which it seemed that approximately 3.5 pounds per acre was left. After a third time over on part of the field, counts indicated about 1.6 pounds per acre remained unharvested.

SUMMARY

1. A tractor-mounted vacuum harvester, designed to pick up short, easily shattered seed heads, has been used successfully in harvesting about 100 acres of ladino clover seed.

2. Taking a 6-foot swath, it covers about 2 acres an hour of working time.

3. One man operated the machine in the field. The trailer is self-loading.

4. Many heads, flat on the ground or tangled in the stubble, may fail to be harvested if the teeth of the pick-up or beater do not throw them up into the air stream.

5. In vegetative growth too short to be handled efficiently with a rake and loader, the use of this machine may at least double the amount of seed obtained.

THE EFFECT OF DIFFERENT ACIDITY LEVELS ON THE HERBICIDAL ACTION OF THE SODIUM SALT OF 2, 4-DICHLOROPHENOXY-ACETIC ACID

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THE EFFECT of various plant extracts and of pH changes on the physiological action of the sodium salt of 2,4-D (this abbreviation will be used for 2,4-dichlorophenoxyacetic acid throughout the paper) has recently been reported (1). It was noted that significant increases occurred in the herbicidal action of the salt of 2,4-D when extracts of Michigan Sweet Spanish onion were used in combination with the herbicide or when the solutions were acidified. The present paper reports additional findings on the effect of organic and inorganic acids at different pH levels, buffered and unbuffered, on the herbicidal action of the 2,4-D salt.

The exact mechanism involved in the herbicidal action of 2,4-D is not known. It is known that some preparations are more effective than others and some plants are more sensitive than others. In general, one finds the esters of 2,4-D more effective in their physiological action on plants than the acid, and the acid form more effective than the salts. The esters are readily oil-soluble, but not water-soluble; ester preparations are usually oil emulsions. While these preparations have, for the most part, been the most effective they have also been the most expensive. They have the additional disadvantage of being more likely to volatilize, and may therefore cause injury to shrubs and trees when sprayed on nearby weedy areas. Also, oil emulsions make cleaning of equipment very difficult. The acid of 2,4-D is not water-soluble and hence carriers, such as polyethylene glycols, are required to bring the acid form into solution. Most of the carriers that have been used for 2,4-D are as expensive as, or more expensive than, the acid itself and therefore materially add to the cost of the final spray mixture. The sodium salt of 2,4-D seems to be the prepa-

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ration most suited to large-scale use of 2,4-D. It is relatively inexpensive, water-soluble, and available in quantity. However, it is not so effective as the acid or the esters. It was suggested by Tukey (2) some time ago that this might be due to the varying degrees of hardness of the water in which the salt was dissolved. A simple method has now been found which will increase the effectiveness of the sodium salt to the point where it equals the commercial acid and ester preparations.

EXPERIMENTAL

The experiments to be described were carried out by dissolving either the sodium salt of 2,4-D or a preparation made by the Dow Chemical Company, containing approximately 70 percent of 2,4-dichlorophenoxyacetic acid and 30 percent sodium bicarbonate, in various acid solutions.

The solutions were prepared by dissolving the preparation of 2,4-D in distilled water, adjusting to the desired pH by the use of the respective acids, and then bringing to the final concentration by the addition of distilled water.

Some solutions were buffered at pH 2.0 or 2.2 by means of a HCl-KCl buffer mixture, others at pH 5.0 or 5.5 with a NaOH-K biphthalate buffer mixture.

The 2,4-D preparations dissolved readily in all the acid solutions used. In some instances the procedure was aided by gentle heating. The solutions were used shortly after preparation; in some cases, however, they were allowed to stand at room temperature for several hours. The acids used in the experiments were the following: sulfuric, oxalic, maleic, o-phosphoric, o-phthalic, l-tartaric, salicylic, fumaric, citric, l-malic, formic, lactic, benzoic, succinic, acetic, isobutyric, butyric, carbonic and boric. In each case the hydrogen ion concentration of the solution was determined.

The prepared solutions were applied, as previously described (1), to the primary leaves of bean plants approximately 10 days after the seeds had been planted. A randomized block design was used in the experiments. Evaluation of the test was made, as described in an earlier publication (1), by weighing the entire shoot growth above the primary leaves. The weight was expressed in grams of total growth on all plants of the same group; it was also established on a percentage basis, the effect of the aqueous 2,4-D salt solution being taken as 100.

TABLE 1—*The effect of pH changes in unbuffered solutions containing 1,000 p.p.m. of the sodium salt of 2, 4-D on the inhibition of shoot growth of bean plants. Fresh weights of bean shoots include all growth above the primary leaves taken 13 days after treatment.*

Treatment	Average weight of shoots per plant*	Average weight of shoots on percentage basis (Aqu. 2, 4–D = 100)
	grams	
1000 p.p.m. salt of 2, 4–D in phosphoric acid at pH 2.50	0.18	17
at pH 3.50	0.52	48
at pH 4.50	0.96	88
at pH 5.50	1.01	93
1000 p.p.m. salt of 2, 4–D in distilled water	1.09	100
Control (untreated)	2.24	206

*46 plants in each treatment.

Fig. 1. The effect of different pH levels of solutions containing 1,000 p.p.m. of the sodium salt of 2,4-dichlorophenoxyacetic acid upon inhibition of growth of bean plants. Plants from left to right treated with (1) 2,4-D salt solution in phosphoric acid at pH 2.50, (2) 2,4-D salt solution in phosphoric acid at pH 3.40, (3) 2,4-D salt solution in phosphoric acid at pH 4.50, (4) 2,4-D salt solution in phosphoric acid at pH 5.50. All solutions were unbuffered. Picture was taken 13 days after treatment.

DISCUSSION OF RESULTS

The results, partially presented in tables 1, 2 and 3, confirm the following facts, some of which have been suggested before (1):

1. The best inhibiting effect is obtained if the pH value of the acid solutions is held between 2.0 and 3.0. If the sodium salt of 2,4-D or the Dow preparation mentioned are applied at these pH levels, the herbicidal action of the preparations is increased to the point where it equals that of the commercial acid and ester preparations. Table 1 presents the data obtained for a phosphoric acid solution. Fig. 1 illustrates the data given in the table. It can be seen that at the lowest pH value used (2.5) shoot growth is completely stopped while at a pH value of 3.5 some growth occurs. At pH values of 4.5 and 5.5 growth is still better and resembles that of an untreated plant although some inhibition and particularly formative effects on the young leaves are noticeable. Jorgensen and Hamner have found that raising of the pH decreases the effectiveness of 2,4-D when applied in soil for destruction of seeds (3). In evaluating the results of the treatments it must be considered that the quantity of 2,4-D applied

TABLE 2—*The effect of various acids and acidity levels in solutions containing 1,000 p.p.m. of 2, 4-D salt upon the inhibition of shoot growth of bean plants. Fresh weights include all growth above the primary leaves taken 13 days after treatment.*

Acid used as solvent	pH value (±0.05)	Ml. of 0.1 N NaOH per 10 ml. of solution	Average weight in grams of shoots per plant
o–phosphoric acid, unbuffered	2	5.8	0.19
	3	0.7	0.23
	4	0.1	0.64
	5	0.03	0.78
o–phosphoric acid, buffered	2	3.4	0.26
	5	1.5	0.28
l–malic acid, unbuffered	2	52.7	0.22*
	3	2.2	0.19
	4	0.14	0.42
	5	0.04	0.72
l–malic acid, buffered	2	29.5	0.23*
	5	0.96	0.23
acetic acid, unbuffered	2	423.3	1.25*
	3	20.6	0.72*
	4	0.47	1.22
	5	0.03	1.52
acetic acid, buffered	2	243.3	0.47*
	5	1.0	0.38
Control (aqu. 2, 4–D salt solution)	7	—	1.04

*Injury to plant tissue at the place of application is responsible for the reduced effect.

Fig. 2. The inhibition of growth of bean plants as a result of treatment with one drop of a solution of 1,000 p.p.m. of sodium salt of 2,4-dichlorophenoxyacetic acid. Plants from left to right treated with (1) a solution buffered at pH 2.2 with a HCl-KCl buffer mixture, (2) a solution buffered at pH 5.4 with a NaOH-K biphthalate buffer mixture, (3) an aqueous solution at pH 7. Picture taken 13 days after treatment.

to each plant is very small, approximately 50 micrograms. However, this method of testing the strength of various 2,4-D solutions will give an indication of what might be expected in field trials of these materials as herbicides.

2. The effectiveness of a certain pH level of the 2,4-D solution depends on two factors: The amount of titratable acid present in the solution and the injury of the plant tissue at the place of application. Generally speaking, higher amounts of titratable acidity in solutions will increase the herbicidal effect, but only to the limit where injury of the plant tissue occurs. The injured tissue will not allow the 2,4-D to be translocated in the plant and thus to exert its physiological effect. It is obvious, therefore, that acidification must take place under due consideration of these facts. In Table 2 and Fig. 2 the conditions

TABLE 3—*Comparison of various acid solutions of the sodium salt of 2, 4-D at 1,000 p.p.m. on the growth of new bean shoots. Fresh weights include all growth above the primary leaves taken 13 days after treatment.*

Treatment	Average weight in grams of shoots per plant
1000 p.p.m. salt of 2, 4–D in:	
phosphoric acid at pH 2.50	0.19
lactic acid at pH 2.50	0.29
acetic acid at pH 2.50	0.78

discussed are shown. A comparison of the plant treated at pH 5.4 with the one treated with an unbuffered solution at pH 5.5 (Fig. 1) reveals that the concentration of hydrogen ions is not the decisive factor. However, Table 2 demonstrates that the amount of titratable acidity is of some significance; hence, it would account for the fact that the plants treated with buffered solutions are more severely affected than those treated with unbuffered solutions at similar pH levels.

3. It seems that weak acids, such as acetic acid, do not have the promoting effect of strong acids, as phosphoric acid. This is shown in Table 3.

SUMMARY

The herbicidal action of the sodium salt of 2,4-dichlorophenoxyacetic acid can be greatly increased by its application in an acid solution.

The pH range of 2.0 to 3.0 of unbuffered acid solutions gives optimum results if sufficiently strong acids are used. The titratable acid (within its non-injurious range) rather than the pH value of a solution accounts for the increased effect of the herbicide.

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THE IMPORTANCE OF SUGAR BEETS TO MICHIGAN FARMERS[1]

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SUGAR BEETS are an important cash crop in adapted areas in Michigan. Sugar beets ranked fourth for the state as a whole among the general crops during 1940-44 in the amount of cash income contributed to the farm business. For those years, navy beans provided an average annual income of approximately 21 million dollars to Michigan farmers, compared with 12 million dollars from wheat, 11 million dollars from potatoes, and 8 million dollars from sugar beets.

TABLE 1—*Sugar beet acreage (lower peninsula), and selected price indexes in Michigan, 1930-45.*

Year	Sugar beet acreage*			Index of beet income per ton**	Index of farm prices	Ratio of beet prices to all prices
	Contracted	Planted	Harvested			
	(thousand acres)			(1910–14 = 100)		
1930	98	89	83	141	144	98
31	70	62	60	111	94	118
32	137	128	123	100	64	156
33	180	164	152	106	73	145
34	153	140	117	134	89	151
1935	144	128	116	130	104	125
36	128	108	100	113	120	94
37	99	88	78	141	132	107
38	143	134	128	139	102	136
39	135	132	126	132	97	136
1940	141	130	119	144	106	136
41	109	106	99	162	129	126
42	153	148	119	173	181	107
43	93	62	50	223	202	110
44	91	73	62	250	199	126
1945	123	92	78	246	211	117

*Source: Farmers and Manufacturers Beet Sugar Association.
**Includes government payments.

[1]This is a slight revision of the August 1946 report prepared for the Carnegie Foundation's Committee on International Economic Policy on the effect of increasing or decreasing the acreage of sugar beets in Michigan on farm income under certain farm price conditions. The report was prepared under the direction of the following committee: representing the industry—A. A. Schupp, Perc Reeve, and Grant Nichol; representing the Michigan State College Farm Crops Department Roy Decker, and Richard Bell; the Economics Department—C. M. Hardin and A. B. Love; and the Farm Management Department—E. B. Hill, A. H. Haist, C. E. Johnson, and K. T. Wright. The committee met to consider the basic assumptions and general procedure, while K. T. Wright assembled the material and wrote the report.

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The production of sugar beets in Michigan has varied widely in the past 15 years. Some of this variation has been due to weather conditions influencing the acreage planted and the tonnage harvested. Price relationships between the price of sugar beets, beans and other farm products, the labor supply, and other factors, have also been instrumental in causing variation in the contracted sugar beet acreage. Table 1 shows sugar beet acreage contracted, planted, and harvested and beet price relationships in Michigan since 1930.

For the years 1930-44, sugar beet income per ton averaged about 25 percent higher than the average index of all farm prices, based upon the 1910-14 relationships. Inasmuch as there was no tendency during this time for the acreage of beets to be increased, farmers in this state apparently feel that the 1910-14 base price of sugar beets is about 25 percent too low in relation to other farm products. When beet prices were more than 25 percent above the level of all farm products, beet acreage was usually increased.

Average prices received by Michigan farmers for some of the more important farm products as an average for 1935-39, 1940-44 and for 1945 are shown in Table 2. Farm product prices in 1945 averaged 90 percent higher than in 1935-39. The factory price of sugar beets in 1945 was 40 percent higher than during 1935-39, but total receipts per ton, including government payments, were about 90 percent higher in 1945, the same increase as for all farm products.

Sugar beet production is centered largely in two general areas in Michigan, the Saginaw Valley, which is the most important, and southeastern Michigan. Farm account records in the Saginaw Valley were

TABLE 2—*Farm product prices and price indexes in Michigan, 1935-39, 1940-44, and 1945.*

Item	1935–39	1940–44	1945
Farm prices			
Sugar beets—(factory price) ton	$6.12	$7.71	$8.60
—(gov't pay'ts) ton	1.37	3.18	5.49
Beans....bu.	3.09	4.95	6.20
Corn....bu.	.66	.96	1.17
Oats....bu.	.34	.57	.69
Wheat....bu.	.83	1.22	1.61
Milk....cwt.	1.73	2.60	3.25
Eggs....doz.	.21	.28	.39
Hogs....cwt.	8.56	10.94	14.20
Price indexes			
Index of farm prices in Mich. (1910–14 = 100)	111	159	211
Prices paid, interest and taxes (1910–14 = 100)	129	148	174
Parity ratio....(1910–14 = 100)	86	107	121

TABLE 3—*Crops and livestock of accounting farmers in Saginaw Valley, Michigan, 1935-39, 1940-44, and 1945.*

Item	All farms—Area 8			One farm
	1935–39 average	1940–44 average	1945	Farm 41—1940–44
Number of farms	113	117	104	1
Acres per farm	139	161	166	121
Tillable acres per farm	105	123	127	111
Percent of tillable acres in:				
Sugar beets	7	6	6	10
Beans	13	15	12	15
Corn	15	15	16	10
Oats	12	12	14	6
Barley	7	6	4	0
Wheat	9	7	10	14
Hay	20	18	19	21
Pasture	11	13	12	20
Other crops	6	7	7	4
Yield per acre:				
Sugar beets ton	9.1	10.1	9.0	10.2
Beans bu.	19	17	16	17
Corn bu.	40	42	28	42
Oats bu.	46	49	54	42
Barley bu.	36	32	36	0
Wheat bu.	29	27	34	22
Hay ton	1.8	1.9	2.1	1.2
Livestock numbers:				
Productive animal units	20.5	26.2	25.7	13.4
Dairy cows	8.7	10.6	11.9	6.8
Sows	1.5	1.8	1.7	.0
Ewes	8	7	5	16
Hens	112	131	127	74

thought to be a good source of data on the relative importance of sugar beets in the farm income, and the influence of changing the sugar beet acreage on farm income. The size of farm, the kinds of crops grown, the yields per acre, and the amount of livestock on the accounting farms in this area, during 1935-39, 1940-44, and in 1945 are shown in Table 3.

Not all farmers in that area grow sugar beets. Most years about two-thirds of the farmers in the accounting project had beets on their farms. The table shows that these account-keeping farmers had an average of 6 or 7 percent of their tillable land in sugar beets. A study of only those having beets reveals that they had around 10 or 11 percent of their tillable land in sugar beets.

One of the accounting farms in the area that is fairly typical of the beet growers has been selected and the column labeled "Farm 41" gives that farmer's average figures for the 5 years 1940-44. It will be noted that he had a little smaller farm and slightly fewer acres of tillable land than the average, with a higher percentage of his land in sugar beets and wheat and less in the feed crops. He also had

about one-half as much livestock as the average of all accounting farmers in the area.

An itemized statement of the income and expense of these farmers during each of two 5-year periods and for 1945 is presented in Table 4. This gives a good idea of the income and expense of the better farmers, with somewhat larger acreages than average farms. It will be noted that during 1935-39 these men with about 140-acre farms had annual receipts averaging $3,296 and expenses of $1,392, leaving a net farm income of $1,904. Deducting interest at 5 percent on their investment, leaves $1,137 as pay for the farmer's labor and management. The operator's labor income during the subsequent 5 years (1940-44) was approximately double that figure. Farm account cooperators in that area for the 10 years, 1930-39, had an average labor income of $492. During that 10 years the parity ratio was 68. The average labor income for 15 years, 1930-44, was $1,073, and the parity ratio during that period was 87.

The income and expense figures of Farm 41, for the years 1940-44, are presented in the last column. This man with a somewhat smaller

TABLE 4—*Financial Summary of accounting farms in Saginaw Valley, Michigan, 1935-39, 1940-44, and 1945.*

Item	All farms—Area 8			One farm
	1935–39 average	1940–44 average	1945	Farm 41—1940–44
Income per farm:				
*Crops	$1,284	$2,116	$2,323	$2,330
Dairy products	796	1,671	2,792	1,477
Cattle	383	601	861	387
Hogs	291	600	659	0
Sheep	79	86	100	215
Poultry and eggs	304	553	791	118
Other	159	190	176	238
Total	$3,296	$5,817	$7,702	$4,765
Expenses per farm:				
Machinery expense	323	647	943	446
Buildings and improvement expense	159	220	312	198
Hired labor	207	316	400	571
Unpaid family labor	185	325	414	6
Feed bought	171	592	819	221
Crop expenses	211	331	464	358
Taxes	79	96	118	83
Other	57	125	192	100
Total	$1,392	$2,652	$3,662	$1,983
Net farm income	1,904	3,165	4,040	2,782
Interest on investment @ 5%	767	931	1,062	721
Operator's labor income	1,137	2,234	2,978	2,061

*During the 1940-44 period the 19.0 acres of beans on these farms provided $798 of the crops sales, the 7.3 acres of beets $606, and other crops $712. Comparative figures for Farm 41 follow: Beans 16.6 acres $697, beets 11.1 acres $944, and other crops, $689.

farm than the average of all cooperators in the area, had about $1,000 less annual receipts during 1940-44, but also lower expenses. His average labor income was $2,061 for the period, compared with $2,234 for all cooperators.

The committee had considerable discussion on the products whose production would be expanded or contracted if the acreage of beets were changed on the farms in the beet areas. The consensus was that in the Saginaw Valley, probably one-half of any change in sugar beet acreage would be reflected in changed acreage of navy beans. The remaining one-half of the change in acreage probably would be divided about equally among corn, small grains and hay. It was decided, however, in figuring the effect of the change in sugar beet acreage, to make all of the change in navy bean acreage rather than spread it as indicated above.

To determine the effect of increasing or decreasing sugar beet acreage on farm income, certain price relationships or the actual price situation at a specified time had to be assumed. The price assumptions agreed to by this committee for figuring the effect of changed beet acreage on net farm income were farm prices at a fourth less than during 1945, and prices paid by farmers the same as in 1945. Prices received by farmers in Michigan during the 1940-44 period averaged 159 percent of 1910-14, or about a fourth lower than 1945. The prices and income during that 5-year period were therefore used as the basis from which to make acreage changes in sugar beets. Farm expenses were assumed to be the same as in 1945. Since the 1940-44 index of prices received by farmers was 159, and the 1945 index of prices paid, interest, and taxes was 174, this gives a parity price ratio of 91.

Sugar beet acreage on Farm 41, which was fairly typical of beet growers, was 11.1 acres during 1940-44. Table 5 presents the effect of one-third more sugar beets, one-third less, and no beets at all in his farm program. The labor income of this particular man with 1940-44 prices for income and 1945 prices for expense was $1,385. This would be increased to $1,545 with one-third more beets, reduced to $1,226 with one-third less beets, and if no beets were grown at all, and the entire acreage put into navy beans, his labor income would be $907.

According to the preceding analysis, raising the acreage of sugar beets one-third on farms with 10-12 acres of beets would add about $160 to their net income. Reducing the acreage a similar amount would lower their earnings an equal amount. Eliminating beets en-

TABLE 5—*Estimated effect of changing sugar beet acreage on Farm 41.*

Item	1940–44 average	1/3 More beets	1/3 Less beets	No beets
Income per farm:				
Crops				
Beans—16.6 acres	$ 697	$ 542	$ 853	$1,163
Beets—11.1 acres	944	1,259	629	—
Other	689	689	689	689
Total	$2,330	$2,490	$2,171	$1,852
Dairy products	1,477			
Cattle	387			
Hogs	0	(Same)	(Same)	(Same)
Sheep	215			
Poultry and eggs	118			
Other	238			
Total	$4,765	$4,925	$4,606	$4,287
Expenses per farm:	(1945)			
Machinery expense	$ 616			
Buildings and improvement expense	258			
Hired labor	781			
Unpaid family labor	0	(Same)	(Same)	(Same)
Feed bought	240			
Crop expenses	540			
Taxes	98			
Other	144			
Total	$2,677	$2,677	$2,677	$2,677
Net farm income	2,088	2,248	1,929	1,610
Interest shown in 1945 records	703	703	703	703
Operator's labor income	1,385	1,545	1,226	907

tirely would reduce the farmer's annual earnings $478. A number of farmers have a considerably larger acreage of beets than indicated above, and the effect of changing the beet acreage on their farms would be correspondingly greater.

Sugar beets require much hand labor. In the past this has averaged about 75 hours per acre. Migratory workers come in each year from Texas and other southern states and perform a large share of this hand work. Sometimes they are called sugar beet laborers, largely because the sugar beet companies have taken the lead in getting the workers here. The accompanying graph shows the migratory labor requirements during the season on sugar beets and the other crops on which this labor works. From this graph it can be seen that the labor requirements for beets and those for other crops more or less supplement each other, and that the total time spent on beets by the workers is considerably less than that spent on the other crops. The leadership taken by the beet companies in getting this labor into the state has been a service to the farmers producing other crops which need such laborers. The fact is, the recent developments in the mechanization of sugar beets, which are likely to result in marked reductions, if not the complete elimination of hand work in beets,

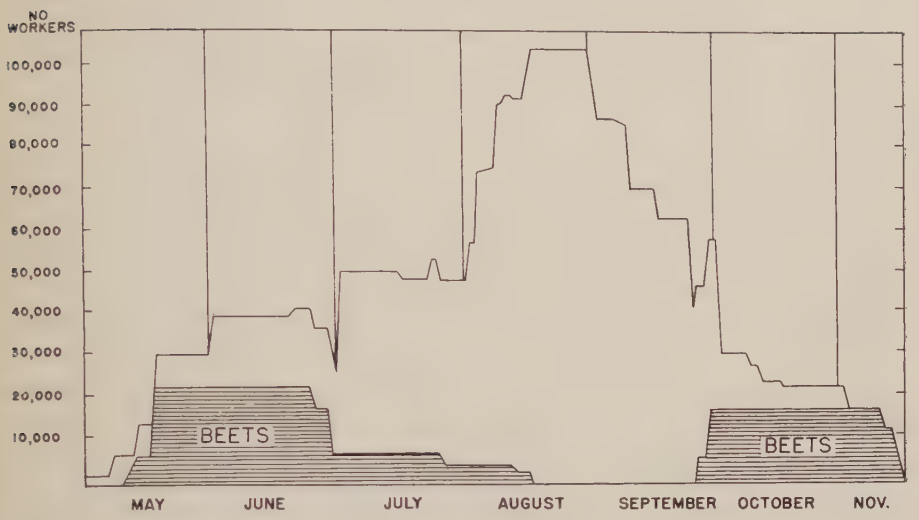

Fig. 1. Migratory agricultural labor requirements in the East North Central States, 1943. (Total requirements, including sugar beets are indicated in the outlined area; horizontal line shading indicates the requirements of sugar beets only.)

will call for leadership on the part of other groups in the securing of hand workers for their crops.

Mechanization of sugar beet production which is under-way in this state and many others no doubt will change the financial picture of sugar beet production from what has been indicated in the preceding tables. With contract labor rates as they are at the present time, in which the acre charge is about $33 for a nine-ton crop of beets, mechanization probably will reduce the cost of sugar beet production. While some of this machinery is relatively expensive, it can still do the job cheaper than contract hand labor. These developments are just beginning and it is difficult to predict at the present time what the future holds for mechanized sugar beet production, but it seems a pretty safe bet that there will be much less hand labor involved than in the past. It is also likely that there will be a tendency for beets to be grown on the larger farms having a larger acreage of beets. Mechanization in agriculture probably will continue—and perhaps at an accelerated rate in the future. The problems of mechanization in beet production, where considerable hand labor has been required, are well on their way to solution and considerable advantage will accrue to sugar beet growers from these developments.

Summarizing, this analysis indicates that a one-third reduction in acreage of sugar beets on farms with 10 percent of the tillable land

in beets would decrease the farm operator's labor income by about 10 percent. The elimination of sugar beets would cause a 30-percent reduction in the operator's labor income under the conditions assumed in this report.

It would seem that the problem is not so simple as merely increasing or decreasing sugar beet acreage by one-third. The problem in reality, is production of sugar beets adequate for farm and plant operation or no sugar beets at all. To be operated on an efficient basis, the industry needs a larger acreage of sugar beets than a one-third reduction would make possible. Present refineries in Michigan could easily handle one-third more beets than are grown at present. To reduce the acreage one-third would put several sugar factories out of business. Millions of dollars are invested in the sugar beet industry in Michigan. It employs thousands of workers. It is an established industry of about 40 years standing. To reduce sugar beet acreage would seriously cripple not only producers but the entire industry. Thus it would seem as though the entire industry, instead of farmers alone, needs to be considered in solving the problems of whether sugar beets should be grown and on what acreage.

BULLETIN REVIEWS

CIRCULAR 205

Remodeling Rural Michigan Homes

Jefferson, C. H., Gerlach, C. S. and Pond, J.

This publication explains some of the more important problems arising in connection with house remodeling. Special attention is given to floor plan arrangement. (44 pp., 72 figs.)

TECHNICAL 204

Results of Spraying and Dusting Trials with Fungicides and Insecticides on Potatoes, 1938-45

Muncie, J. H. and Morofsky, W. F.

Results are reported on trials with various copper containing fungicides, including yellow cuprocide, bordeaux mixture, Bordow, tribasic copper sulfate, Cupro-K, Coposil, Basicop, Oxobordo, Copper Hydro, Dithane and Zerlate. Insecticides included derris, pyrethrum, rotenone, nicotine sulfate, calcium arsenate and DDT. These materials were used in various concentrations, together with such amendments and stickers as bentonite, calcium lime and magnesium lime. (23 pp., 13 tables)

JOURNAL ARTICLE ABSTRACTS

The Nutritive Value of Fish from Michigan Waters. 2. Thiamin of Lake Herring, Carp, Common Sucker and Smelt

Klocke, J. P., Tack, P. I., Ohlson, M. A., Nitchals, R., Leffler, E., and Henry, N. S.

Food Research. 12: 36-43. 1947. [*Journal Article 780 (n. s.) from the Michigan Agricultural Experiment Station*]

The effect of freezing, refrigeration, holding, baking, frying and possible seasonal and environmental conditions on the thiamin content of lake herring *(Leucichthys artedi)*, and common suckers *(Catostomus c. commersonii)*, carp *(Cyprinus carpio)*, burbot *(Lota lota maculosa)* and smelt *(Osmercus modax)* have been studied. The fish were analyzed by the thiochrome method after digestion with enzyme Polidase-S.

Lake herring caught in May and June averaged 0.89 micrograms of thiamin per gram of fresh tissue. During the fall spawning season the average was 0.58 ug. per gram and in January and February the average was 1.12 ug. per gram. The herring from Green Bay averaged 0.86 ug. per gram of thiamin and from Saginaw Bay 0.87 ug. per gram.

Burbot averaged 3.78 ug. of thiamin per gram of fresh tissue. No thiamin was found in the carp, smelt and common suckers analyzed. Thiamin destruction by an enzyme found in some raw fish tissue has been reported.

Herring frozen, then stored, lost an insignificant amount of thiamin in 11 months. Burbot appeared to increase in thiamin due to a decrease in moisture. Refrigeration at 4° C. for 48, 120 and 137 hours resulted in some loss in two groups of herring. Baking resulted in an insignificant loss of thiamin in herring and there was 88 to 84 percent retention during frying.

Lake herring may be considered a good source and burbot an excellent source of thiamin.

A Crop Rotation Field Layout with an Illustration of the Statistics Involved in Combining Several Years Data

COOK, R. L., MILLAR, C. E., AND ROBERTSON, L. S.

Soil Science Society of America Proceedings. 10: 213-218. 1946. [Journal Article 800 (n. s.) from the Michigan Agricultural Experiment Station]

A crop rotation and sequence experiment was established in 1940 on Brookston clay loam. Seven rotations, all including sugar beets, are being studied. Plots are replicated four times. All crops appear each year. Each rotation is conducted at two fertility levels. The plots are arranged in a split-plot, randomized block design.

The statistical analysis of the sugar beet yields during the first 5 years is presented in sufficient detail to make it possible for one with very little statistical training to use it as a guide in analyzing the data from a similar experiment. The analysis of variance for 1941 is given in detail. Because of the two fertilizer rates there are 56 beet plots each year. The total degrees of freedom are 55. Degrees of freedom for blocks is 3 and for rotation 6. The interaction blocks X rotations is used as the error term (a) for rotations. Levels then accounts for 1 degree of freedom, and levels X rotations for 6. This leaves a remainder of 21, the error term (b) for levels.

In combining several years' data, the total degrees of freedom is one less than 56 times the number of years. Variance is taken out for years and for years X rotations. The blocks degrees of freedom is directly added for each year, or in other words, it becomes three times the number of years being combined. (Since there are 4 blocks) Levels degrees of freedom remains 1. The variation caused by the interactions levels X years and levels X years X rotation is subtracted from the total variance, leaving the error term "b".

The significance of the variance caused by rotations was not consistent through the years. The interactions years X rotations and years X levels were highly significant in the 3, 4 and 5 year combinations. This emphasizes the importance of season in sugar beet experiments and brings out the fact that many years' results are desirable before conclusions are drawn.

The Relationship of Nicotinic Acid, Tryptophane and Protein in the Nutrition of the Pig

LUECKE, R. W., MCMILLEN, W. N., THORP, F. AND TULL, C.

Jour. Nutrition. 33 (3): 251-261. 1947. [*Journal Article 838 (n. s.) from the Michigan Agricultural Experiment Station*]

A high-protein, nicotinic acid-low corn ration was fed to a group of weanling pigs whose average weight was 27 pounds. The ration was supplemented with ample amounts of thiamine, riboflavin, calcium pantothenate and pyridoxine. After 4 weeks on this ration the animals became rough-haired and unthrifty. Autopsy revealed gross lesions limited to the colon. These included thickening, congestion and yellowish caseated material on the surface of the mucus membrane. When this same ration was supplemented with nicotinic acid and fed to another group of pigs good growth resulted and no gross pathology was found.

When the protein content of the same ration was lowered to 14 percent and fed to a third group of pigs, diarrhea developed during the fourth week; the animals lost weight, became rough-haired and emaciated. Autopsy revealed severe lesions of the large intestine but particularly of the colon.

To another group of pigs the same low-protein ration was fed, plus daily supplements of 200 mg. of d, l-tryptophane per pig. Good growth resulted and the animals had a normal healthy appearance. Autopsy revealed that two of the five pigs had very minor lesions of the colon. No diarrhea developed in this lot.

No symptoms of nicotinic acid deficiency could be noted in pigs fed a low protein ration composed largely of ground whole oats.

The Production of Forage Crop Mixtures under Different Systems of Management, the Consequent Effect on Corn Yields and the Re-establishment of Alfalfa

HARRISON, C. M., BROWN, H. M., AND RATHER, H. C.

Jour. Amer. Soc. Agron. 39 (3): 214-223. 1947. [*Journal Article 845 (n. s.) from the Michigan Agricultural Experiment Station*]

Four different mixtures of legumes and grasses were subjected over a 3-year period to three different systems of management, namely, pastured continuously, first crop cut for hay and second crop pas-

tured, and cut for hay continuously. Corn was then planted and following the corn, alfalfa was reseeded with and without fertilizer to test the effects of the various mixtures and management practices on yield of corn and establishment of alfalfa. Yields of hay, gains made by sheep and sheep days were approximately doubled where alfalfa was present in the mixture in comparison with straight grass or red clover-grass mixture. There were relatively small differences if any, between the various mixtures used in their influence on yields of corn but variations in management resulted in quite wide differences. Likewise, the management practices used on the various mixtures influenced the stand establishment and yield of alfalfa when it was reseeded with and without fertilizer following corn. Corn and alfalfa yields were significantly higher where a given preceding mixture was pastured rather than cut for hay or used for both hay and pasture.

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